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EDITORIAL NOTES

A MATTER OF SUBSIDENCE

WE cannot think we envy Mr. Charles Ingham, who is Engineer, Manager, and Secretary of the Cannock District Gas Company, Ltd., in his task, among many other items peculiar to his particular area, of controlling the vagaries of his distribution system. But we do congratulate him on the steps he has taken and is continuing to take to minimize as far as possible the unfortunate results of subsidence in a mining area where thick shallow seams of coal are worked—unfortunate results certainly as far as unaccounted-for gas is concerned. At the present time the figure is something like 23%. His efforts to reduce this percentage are commendable, and typify the resource and ingenuity which are well known and well merited characteristics of the gas engineer. Of course, not only is a loss of gas of this order unpleasant on paper and in cash value ; it also means the expenditure of much labour, time, and money on the district to maintain not only continuity of gas service, but safety for the community. Mr. Ingham recounted his experiences and described his methods of remedy in a highly interesting article which we published in last week's " JOURNAL " (p. 115). He did not suggest that this figure of 23% for unaccounted-for is inevitable. Great efforts are being made to reduce it, as is obvious from the article, but, quoting from it, " there is little doubt that . . . a fairly high figure must be expected." Mr. Ingham is not alone in his misery ; other undertakings in mining areas have similar problems, but his trials are many. Long straggling villages with long stretches of open country between, result naturally in low consumption per service pipe, and great lengths of main per consumer—factors in themselves tending to give a high unaccounted-for gas figure under the best of conditions. And, as Mr. Ingham tersely remarked, when they are coupled with mining subsidence such as occurs in the Cannock Chase Coalfield, it becomes a certainty.

In mining areas there is the practice of giving " allowance " coal. A married coal miner receives nearly a ton of coal every month free of charge at the pit. This, quite obviously, is not conducive to a high consumption per consumer figure. Yet, the " convenience factor " enjoyed by gas has untold value, and it is remarkable—given the faith and the will—what can be sold even under the most obstinate and unlikely conditions. The " convenience factor " is dependent on adequate pressure of gas and constant and ample supply. In face of difficulties of no mean order, Mr. Ingham is achieving these two desirable and necessary aims. The difficulties ? A recent test of a length of about 500 yards of 6-in. main showed a leakage of 420 cu.ft. per hour—over 3 million cu.ft. a year. There was no obvious indication of trouble. About sixteen services were found to be broken off, and two or three main joints were drawn. Within six weeks of curing all leakage on this particular length it became necessary to repair two of the services which had been repaired a few weeks earlier. This exemplifies the nature of the difficulties encountered.

The remedies ? Constant vigilance and, as we have said, the exercise of ingenuity. The use of ethyl mercaptan has been tried, and a dog has been purchased, presumably with a keen and highly sensitive nose, to smell out gas leaks rendered the plainer and, on the smell of them, more disagreeable. We cannot say that we envy this dog ; he must lead a " dog's life." Nor can we blame him from ceasing to scratch his paws on a concrete or macadam surface after a short while, and in spite of enthusiasm to become a renowned dog-chemist. The results of the dog's work to date are, we are told, inconclusive. However, " where mains are laid in the grass verges of country roads or across fields there seems reason to hope that the dog may save time and money, and, similarly, he should be helpful in tracing leakages in service pipes passing through gardens." Is it too much to hope that in time he may become ancestor to an honourable line of Gas Industry smelling-dogs ?

In regard to vigilance, the whole of the mains of the Cannock area are patrolled constantly, with, naturally, special emphasis on the worst areas. One man has this as his sole duty. There are normally two gangs of men testing for and dealing with escapes, but at some times there may be four or five gangs on this work. The worst leakages, Mr. Ingham pointed out, are not the large ones, for these are quickly reported and rapidly located. The biggest difficulty arises from small leaks caused by the drawing of hundreds of lead joints small distances. These are not easy to detect or locate. As we have said, a test of about 500 yards of 6 in. main showed a leakage of 420 cu.ft. per hour—over 3 million cu.ft. a year. No report had been received from residents, nor was there any obvious indication of trouble beyond certain unevenness in road surfaces. And for repair work in his area, Mr. Ingham spoke very highly indeed of the efficacy of the Dresser clamp. This type of joint allows of considerable angular movement, and the Author remarked that for nearly three years he has fixed these couplings on drawn joints, and has yet to find the first joint which has leaked after this treatment. Mr. Ingham's highly interesting account should prove helpful to other gas engineers whose areas are subjected to exceptionally severe conditions.

B.C.G.A.

WE published in last week's " JOURNAL " a substantial portion of the 29th Annual Report of the General Committee of the British Commercial Gas Association, which covers the Association's activities to September last. We think it will be agreed that, in very changed circumstances, the record presented is a remarkably good one ; we certainly regard it as encouraging—particularly from the point of view of maintaining public interest and goodwill. The circumstances in wartime are certainly different from those which prevailed pre-war. The accounts (these relate to the year ended March 31, 1940) show an income of £76,000, compared with £121,000 the previous year, these being round sums. Expenditure for the current financial year is not expected to exceed £42,000, and members will receive a further refund. Expenditure was decreased under practically all headings, particularly that of publicity. The Association's wartime staff numbers at present 27. At the outbreak of war the staff numbered 73.

Despite these difficulties and other limitations necessarily imposed, work in many directions has been carried out with extremely good results. In regard to editorial publicity, for example, and notwithstanding smaller newspapers, gas was kept prominently in the Press throughout the twelve months under review. Then there have been the co-operative efforts in connexion with the National Food Campaign—to which we have referred from time to time in these columns—the inauguration of a regular Folder Service for the information and enlightenment of members, the work of the Studio in furnishing topical showroom window display material, the preparation of suitable wartime lectures, and continuation of the Association's film service. It is good to learn that the number of borrowers

of these films is growing rapidly, and that during the year a matter of 2,500 reels of film were loaned and shown to a total estimated audience of well over half a million. What can be done by the B.C.G.A. in the interests of the Gas Industry under present conditions is being done, and is being accomplished very well indeed.

Tar Oils

THE Mines Department and the Ministry of Transport have decided to introduce a scheme to promote the use as fuels for commercial motors of certain coal tar oils, such as creosote and similar products (excluding light oils and heavy oils). We understand that the scheme will come into operation on Friday next, and will be subject to review after six months. The aim is to encourage experimental work on the use of these oils with a view to reducing the consumption of imported fuels. The scheme is that users of coal tar oils of the nature referred to will be granted additional ration coupons on a scale which will enable them to cover extra mileage with their vehicles in which the coal tar oils are used. Subject to the approval of the Regional Transport Commissioner, additions will, we understand, be made to the basic ration and to any supplementary rations granted. The original basic ration will be increased by the ratio which the coal tar oil bears to the whole mixture, and the increased ration will then be apportioned between the imported fuel and coal tar oil according to the nature of the mixture to be used. For example, taking a declared mixture of 75% imported fuel and 25% creosote, an addition of 25% to the old basic ration will be allowed. In cases where a dual carburetter is used, one-half of the ordinary basic ration of petrol will be allowed, together with coupons for coal tar oils sufficient to provide up to 100% more units of fuel than would have been permitted if no coal tar oil was employed. Coal tar oils used as motor fuel can be sold or acquired only on the surrender of valid coupons, except under the authority of a licence issued by the Secretary for Petroleum ; and it is proposed (Motor Fuel Rationing (No. 2) Order, 1940) that only producers of coal tar oils should receive licences authorizing them to use such oils in vehicles registered in their own name. Considerable work on the employment of creosote for commercial vehicles has already been carried out by certain gas undertakings in this country and in Northern Ireland, and even under peacetime competitive conditions showed promise and achieved a measure of success. With events moving as they are to-day this experiment and investigation should stand the nation—and the Gas Industry—in good stead.

"Those Loyal and Brave Repair Gangs"

These words form the heading of a double page in the new issue of the Gas Light & Coke Company's *Co-partners' Magazine*, on which appear a number of letters of appreciation, chosen from among many others, which have been received from the general public, and express their gratitude for the splendid service which the Industry has rendered in the face of the greatest difficulties. The letters come from many different parts of the Gas Light & Coke Company's territory, and are from all classes and sections of the community. The Secretary of a hospital writes, "I wish, on behalf of the hospital, to express our appreciation of the very efficient and rapid manner in which repairs were effected to the hospital supply of gas after a bomb had fallen in the road outside, resulting in the complete dislocation of the light, water, and gas supplies to the hospital." The Manager of a block of flats, the secretary of a householders' association, a group of women consumers, and the managing director of a large firm, are also among those who have sent letters from which we might quote expressions of appreciation of the rapid and efficient work which has been carried out in the midst of many difficulties and dangers.

In peacetime the general public looked on the telephone as a matter of course, turned on the gas tap or the water without a thought ; but in the last few months they have begun to realize how much the public services mean to them, and how difficult it is to do without them. Such expressions of gratitude not only show how the people are thinking, but they are also an encouragement to those who, night after night, are facing dangers in so important a sphere of national service. Though thanks are the last thing in the world these brave men would expect for doing so magnificently the job of work they have set themselves to do, we are pleased to learn from the Gas Light and other companies' magazines that such letters are arriving in large numbers.

Personal

Presentation to Mr. Holton

Mr. ALFRED L. HOLTON was the chief guest at a luncheon held in the Engineers' Club, Manchester, on Friday, Jan. 10.

After the luncheon, Sir Frederick J. West read several apologies, including one from Mr. George Dixon, the President of the Club. He stated that it had been decided that Mr. Holton's retirement from the position of Chief Engineer to the Manchester Corporation Gas Department should not pass unnoticed by his many friends in the Gas Industry. Mr. Holton had therefore been asked to attend the luncheon. Sir Frederick West then called upon Mr. J. Bridge (Elland) to make a presentation to Mr. Holton.

In making the presentation Mr. Bridge referred in affectionate terms to his long association with Mr. Holton, which extended over a period of 36 years. It dated from the time he was a youth in the Manchester and District Junior Gas Association, when Mr. Holton did such an enormous amount of spade work for that Association. He had put it on a solid foundation, and he had never lost interest in its activities over a period of 40 years' membership. Again, he had the pleasure of being Hon. Secretary when Mr. Holton was President of the Manchester District Association of Gas Engineers in 1936. He had great pleasure in asking Mr. Holton to accept a walnut cabinet as a memento of the occasion, and also the good wishes of all for a long and happy retirement.

Mr. Holton thanked all those who had been associated with the gift. Nothing gave him greater pleasure than the fact that Mr. Bridge had been chosen to make the presentation. They had many things in common and they had both worked together for the good of the Industry.

In closing, Colonel W. M. Carr reiterated the good wishes of all present that Mr. Holton would have good health and that he might long be spared to be of further service to the Industry.

* * *

The marriage took place on Jan. 6 of FRANK RADCLIFFE, M.D., O.B.E., of Harley Street, eldest son of the late Professor Radcliffe, of Manchester University, and Ida Laura, only daughter of Mr. G. A. Mallett, General Manager and Secretary of the Ipswich Gas Light Company and the late Mrs. Mallett.

* * *

The Lanark County Council have agreed to recommendations of the Gas Committee that Mr. THOMAS F. GRIEVE, of the Glasgow Corporation Gas Department, be appointed Works Superintendent ; and that Mr. HARRY FIRTH, of the St. Helens Gas Department, be appointed Distribution Engineer and Sales Manager of the County Gas Undertaking.

* * *

The Warrington Town Council has confirmed the recommendation of the Gas Committee appointing Mr. W. A. Cook, of Oldham, to the position of Works Superintendent of the Gas Department, Warrington, in place of Mr. L. A. Ross, who recently left to take up a similar appointment with the Bristol Gas Company. Mr. Cook is at present Assistant Chemist and Relief Shift Engineer at the Higginshaw Works of the Oldham Corporation.

* * *

Under the Government Precautionary Scheme for Scotland, Mr. R. J. PHILP, who has just completed 25 years' service as Manager of North Berwick Gas-Works, has been appointed group leader of Gas Works for the County of East Lothian.

Obituary

Ex-Baillie JOHN A. SANGSTER, whose death has taken place at the age of 76, was for a very considerable period Convener of the Committee of the Corporation Gas Undertaking at Aberdeen.

Cheltenham's New Club Rooms

An interesting event in the history of the Cheltenham & District Gas Company took place on the evening of Monday, Nov. 25, when in the presence of a big attendance of employees the new Club Rooms were opened by the President of the Club, Mr. A. L. Morris (General Manager). In his opening remarks he pointed out that the scheme had been in hand prior to the outbreak of war and the delay in opening had, of course, been occasioned by the difficulties brought about by the war, but he was sure that in spite of this and the additional calls that had been made on the employees the conveniences of the Club Rooms would nevertheless be appreciated.

Special thanks were extended to Mr. A. Sledge, the Secretary, and his predecessor Mr. Singleton (now serving with H.M. Forces), Mr. A. C. Dunn, the Treasurer, and many other employees who had devoted a lot of their spare time to the preparation of the building, in which provision is made for darts, table tennis, cards, and a very comfortable bar. In addition, certain rooms have been set aside for the use of the ladies.

A very pleasant surprise was reserved for the President when the youngest club member stepped forward, and with a few appropriate words presented him with a silver tankard as a souvenir of the occasion.

Institution of Gas Engineers

New Vice-President

At the Meeting of the Council of The Institution of Gas Engineers held on Jan. 14, 1941, a letter was received from Mr. R. W. Hunter, M.Inst.C.E., London, tendering his resignation on grounds of ill-health from the office of Vice-President of the Institution, to which he was elected in June, 1939, and from the Council and the Committees of the Institution of which he had been a member. The Council expressed their deep regret at the necessity for this action, and their sincere appreciation of the services rendered to the Institution by Mr. Hunter in the past.

The Council resolved to appoint Mr. E. V. Evans, O.B.E., F.I.C., London, to serve in place of Mr. Hunter as a Vice-President of the Institution, in accordance with By-law 52.

Mr. C. M. Croft, D.L., J.P., London, was elected by the Council to fill the vacancy on the Council of the Institution created by the recent death of Mr. C. Valon Bennett.

National Gas Council

Meeting of Central Executive Board

A meeting of the Central Executive Board of the National Gas Council was held at Gas Industry House, London, S.W. 1, on Tuesday, Jan. 14; Sir David Milne-Watson, Bart., LL.D., D.L., was in the Chair.

The late Mr. C. Valon Bennett.—The Chairman referred with deep regret to the loss sustained by the Industry in the death of Mr. C. Valon Bennett, who was the Engineer, General Manager, and Secretary of the Rochester, Chatham & Gillingham Gas Company. He had been connected with the National Bodies over a period of some 25 years, and had always been a loyal supporter of the Council. He would be greatly missed, not only for his work in the Industry, but as a friend and colleague. A vote of sympathy with his family was passed, the members standing in silence.

Resignation of Mr. T. P. Ridley, F.C.I.S.—It was reported that a letter had been received from Mr. Ridley, tendering his resignation as a member of the Board upon retirement from his office of General Manager and Secretary of the Newcastle-upon-Tyne and Gateshead Gas Company. Ever since the formation of the Council in 1916, Mr. Ridley had rendered the most valuable services to the Industry, and among his many activities he had been Chairman of the Northern District Executive Board for many years. The Board were unanimous that in order to secure the retention of his services to the Industry he should be nominated an Honorary Member of the Council, for election at the next General Meeting.

Coal.—The coal question as affecting the Gas Industry was discussed under the following headings : (*a*) Price. (*b*) Supplies and Transport Difficulties. (*c*) Standard Conditions. (*d*) Demurrage. (*e*) Expiry Date of Contracts. Appropriate action was agreed in connexion with all these subjects.

The following were appointed to represent the Council on the Council of the Conjoint Conference : Messrs. J. H. Cadman, R. Halkett, J. Jamieson, A. W. Smith, H. C. Smith, R. W. Foot (in place of Mr. T. Hardie, resigned).

It was agreed to ask for the exclusion from the War Damage Bill of all public utilities, and that they should be made the subject of a separate Comprehensive Bill.

It was reported that representations had been made by the Conference to the Ministry of Home Security that the ruling and practice of the London Civil Defence Region in regard to reinstatement of highways necessitated by enemy action should be adopted throughout the country.

It was reported that, in conjunction with the Railway Companies, the Conference was urging the Government that the uniform and clothing purchased by public utilities for use by their employees should be exempt from the purchase tax.

It was reported that owing to the difficulty of calling full metings at the present time, an Emergency Committee had been set up by the Conference to deal with the War Damage Bill and to consider and take such steps as might be deemed advisable in connexion with any matters of urgency. Mr. A. W. Smith and Mr. R. W. Foot had been appointed to represent the gas interests on this Committee.

It was stated that the Ninth Annual General Meeting of the Conjoint Conference would take place at Gas Industry House on Wednesday, Jan. 29, at 12.30 p.m., when the President, Lord Falmouth, would preside. Apart from the circulation of the Annual Report, the business would be entirely formal in character. It was left to the Officers to obtain the necessary representation in order that a quorum might be secured.

Income Tax.—It was stated that negotiations with the Inland Revenue with regard to income tax depreciation allowances in respect of plant and machinery had now been completed, and the form of agreement which had been generally approved by the Board of Inland Revenue had been circulated to members of the Board. A vote of thanks was passed to the Council's Income Tax Committee for their services in regard to this matter.

It was agreed that the next meeting of the Board should take place at Gas Industry House on Tuesday, Feb. 11.

Each Monday and Friday until further notice at the Southport Corporation Gas Showrooms, Mrs. E. M. Mate, domestic science mistress, will prepare and give gas cookery demonstrations, and Mr. T. Bowen Partington will talk on Keeping Fit in Wartime.

The Tale of the Rates

Interesting Analysis of Municipal Affairs

In these days of high taxation and generally increased cost of living the incidence of local rating is a matter of some moment. For this reason a study of Mr. Allison Davies' annual statement of rates levied in various towns is of more than usual interest. Mr. Davies is the Preston Borough Treasurer, and the present statement is the 56th in the series. It sets out the rates levied in 349 municipal areas, together with the appropriations by the different services, totals of population, rateable value per head, and particulars relating to gas, water, and electricity supply. It may, in fact, be claimed that this " tale of the rates " discloses the general trend of municipal affairs throughout the country.

It should, of course, be appreciated that the rates levied in the pound must not be taken as representing the actual burden imposed upon the ratepayer in comparison with the corresponding figure for another town. For where the figure in the pound may be high, the rateable value may be low, and *vice versa*. The figures do, nevertheless, when set against those of the previous year (as they are in these returns), demonstrate the general tendency in the area concerned.

Viewing the figures in their broadest aspect, the picture is—perhaps rather surprisingly at first sight—somewhat less gloomy than of recent years, though this may be accounted for in some measure by a revival of industry in certain previously " depressed " areas consequent upon wartime requirements. The fact remains, however, that the greater calls made upon municipalities generally have led to increased rates in 41.5% of the areas covered by the returns. On the other hand, no less than 22.3% record decreases, the remaining 126 areas showing no change.

Of the 28 Metropolitan Boroughs included in the returns, 24 have increased their rates, while two—Bermondsey and Greenwich—show reductions. Bethnal Green and Wandsworth have the highest and lowest rates at 19s. and 12s. 4d. respectively, the average having risen by about 8d. to 14s. 2d. in the pound. In the 84 County Boroughs, the average has increased from 14s. 5⅜d. to 14s. 9d., a total of 36 authorities showing increases and 13 decreases. Bournemouth has the lowest figure at 7s. 11d. in the pound, while Merthyr Tydfil heads the list at 30s. 6d. Of 162 Boroughs, 61 show increases and 38 decreases, resulting in a rise in the average from 13s. 5⅜d. to 13s. 7½d. In this category Worthing has the lowest figure at 8s. 7d. and Port Talbot the highest at 20s. The figures for the 75 Urban Districts are chiefly noteworthy for the fact that for the first time for many years the decreases at 25 exceed the increases—though admittedly by only one. In spite of this, however, the average has risen by ¼d. to 15s. 5⅜d. Under this heading Walton and Weybridge and Abertillery occupy the opposite ends of the scale at 9s. 5d. and 26s. 6d. respectively.

Among particulars of the domestic services, the returns give the prices of gas per therm and per 1,000 cu.ft. within and without the districts named, together with the declared C.V. of the gas supplied. Other details of interest are the estimated transfers from municipal undertakings in relief of the rates and, conversely, the estimated transfers to undertakings to offset deficiencies. Of the latter there are nine instances among gas undertakings, making an aggregate charge upon the rates of nearly £50,000. This is larger than in recent years. On the other hand, twelve municipal gas undertakings contribute between them rather more than £78,000 (estimated) towards the relief of the rates. This is considerably less than in previous years, and gives some indication of the greater calls being made upon gas undertakings generally. In this connexion it should be pointed out, however, that the returns are not intended to demonstrate the desirability or otherwise of municipal trading, or the use of profits therefrom for relieving the rates. Indeed, the vast majority of municipal gas undertakings continue to operate on a " self-supporting " basis.

University of Leeds

Special Courses in the Fuel Department

A series of six lectures will be given in the Lecture Theatre of the Mining Department by Mr. J. Crossland, Lecturer in Mining in the University of Leeds, on Mondays, at 2 p.m. and 3.30 p.m., during the second term, commencing Jan. 13 and concluding Jan. 27.

A course of two lectures will be given by Mr. H. J. Hodsman, Lecturer in Gas Chemistry in the University of Leeds, at 2 p.m. and 3.30 p.m., on Thursday, Feb. 6, 1941.

A series of six lectures will be given on Mondays commencing Feb. 24 and concluding March 10 : (A) Two lectures by Mr. J. E. Davis, South Metropolitan Gas Company, at 2 p.m. and 3.30 p.m., on Monday, Feb. 24. (B) Two lectures by Mr. Dean Chandler, Chief Technical Officer (District), South Metropolitan Gas Company, at 2 p.m. and 3.30 p.m., on Monday, March 3. (C) Two lectures by Mr. D. C. Gunn, Yorkshire Industrial Gas Development Centre, at 2 p.m. and 3.30 p.m., on Monday, March 10.

A series of eight lectures by Mr. T. H. Blakeley, South Yorkshire Chemical Works, Ltd., Parkgate, will be given on Mondays at 2.0 p.m. and 3.30 p.m., commencing Jan. 27 and concluding on Feb. 17.

A course of four lectures will be given by Dr. A. L. Roberts, Lecturer on Refractory Materials in the University of Leeds, at 2 p.m. and 3.30 p.m., on Tuesdays, Feb. 4 and 11.

A course of two lectures will be given by Mr. A. Preece, Lecturer in Metallurgy in the University of Leeds, on Thursday, at 2 p.m. and 3.30 p.m., on Feb. 13, 1941.

WARTIME ASPECTS OF BENZOLE RECOVERY*

By KENNETH SHEARD, B.Sc., Newton Chambers & Co., Ltd.

WHEN the request was received from your President that a Paper should be given on the subject of benzole recovery, the main question which came to mind was not what to say, but what could be said, regarding benzole which had not already been fully dealt with in the past. The whole subject from both technical and economic standpoints seemed to have been discussed very thoroughly. The Author well remembers the controversy in the Technical Press between two Scottish undertakings concerning the economic side of the question. There was, however, one aspect which suggested itself which had the merit of being inevitably of a topical nature—namely, the effect of the changed conditions brought about by the war on the subject as a whole.

No one can doubt the need at the present time for as much home-produced motor spirit as possible. We live on an island which has, practically speaking, no natural sources of petroleum supply, and the requirements have, therefore, to be met by imports or by home production. The more home production can be increased, by so much can imports be reduced, with consequent release of shipping for other duties, the importance of which under present conditions requires no emphasis. Moreover, crude benzole as produced from coal carbonization in coke ovens, horizontal or vertical retorts, has many advantages over some of the imported fuels. It is an important source of toluene, in some cases up to 15–20%, which is required in large quantities for the manufacture of explosives. In the refined state, benzole has a high octane number, and consequently finds extensive use in improving the anti-knock properties of petroleum fuels used in modern internal combustion engines of high compression ratio, such as aircraft engines and the like.

The position with regard to home-produced fuels was extensively reviewed by the Falmouth Committee, and the findings were published in February, 1938. This report, of course, referred to peacetime conditions. Since the outbreak of war the position has again been the subject of Government investigation, but in this case for obvious reasons the results have not been made public. One fact is, however, certain—namely, that the wartime requirements for motor spirit are greater than those in peacetime.

During the past ten years there has been a steady increase in the production of benzole at gas-works, but up to a few years ago on the basis of tonnage of coal carbonized, while 98% of the coke oven plants recovered benzole, at gas-works the recovery was representative of only approximately 50% of the total coal carbonized, at an average yield of between two and two and a quarter gallons per ton, as against over three gallons per ton at coke ovens. It was fully realized that the difference was due to the particular economic and statutory conditions in the two industries, and in the case of the smaller undertakings the capital cost of installing recovery plant was quite a serious item.

In 1936 about 20 million gallons of crude benzole were produced at gas-works in this country, yielding some 12½ million gallons of motor spirit. This amount, though seemingly large, represented only about 1% of the total requirements. If it had been possible for all gas-works to extract benzole to the extent practised at coke ovens, a further 20 million gallons of motor benzole would have been available, representing in all some 2½% of the amount required in peacetime. Since that date, however, much has been done towards increasing the quantity of benzole recovered, and the production of crude in 1940 is estimated to be well in excess of that in 1938.

While this increase is of great importance, there still remains a considerable quantity which could be recovered. Based on wartime consumption this would not represent a very large percentage of the total requirements, and may seem somewhat disheartening, but it would be a step in the right direction, and if the recovery could be done profitably, so much the better.

Arising out of the work of an earlier Committee with a view to improving the position throughout the Industry, the Advisory Committee on Benzole Recovery was appointed on the auspices of the Mines Department in June, 1940, and on this Committee are representatives of the Gas and Coking Industries. Contractors were represented through the Society of British Gas Industries, and I am permitted to refer this afternoon to some of the work carried out by this Committee. A preliminary investigation showed that a large number of undertakings, mainly of the medium and small size, and quite a few of the largest works, had previously decided against the recovery of benzole. In several instances, however, the position was reviewed and the installation of the necessary plant undertaken. Whole-time technical officers were appointed by the Committee to act in an advisory capacity so as to afford every assistance to gas-works and coke ovens in connexion with the installation of new plant, and also with regard to improving the efficiency of existing plant. The Committee also had the generous voluntary assistance of engineers and many gas and coke oven undertakings who were willing to give their colleagues in their respective districts the benefit of their experience.

It was realized at the outset that in the case of the smaller undertakings carbonizing up to 15,000 tons of coal per annum, the capital cost of a scrubber of the static type, together with stripping plant, tanks, &c., had been a serious problem when considering the financial aspect of recovery, and it seemed that the needs of such works could best be served by a plant which may not only embody all the features of each particular contractor's normal type, but would satisfy the following requirements :

1. It should have a high standard of efficiency.
2. It should be simple in design and operation.
3. The initial cost should be low.
4. The time required for construction and installation should be as short as possible.

The last item was a most important factor.

To meet these requirements the course adopted by the contractors was to develop a plant of standardized design for each of three sizes of works, of half, one, and one and a half million cu.ft. of gas per day. The various contractors whose representative is a member of the Advisory Committee submitted designs, &c., together with estimates of the selling price of the respective units. Subject to the consent of the Committee, an approved list of contractors was made, and undertakings were advised accordingly in connexion with any work of this nature they had to place.

In the recovery plant designed particularly for these smaller works by the firm with which the Author is connected, the tower scrubber is divided into two parts by a double partition, the two sections being filled with Lessing stoneware rings. The gas flows upwards through the first part, down between the two division plates, and upwards through the second portion of the scrubber, the flow of gas and wash oil being counter-current.

The debenzolized oil is pumped to the top of the gas outlet section of the scrubber, becoming partly saturated in its flow down the compartment, and then pumped to the top of the gas inlet section. A certain amount of recirculation takes place in this section to ensure as high a concentration of benzole in the wash-oil as possible.

The delivery line of the oil circulating pump is tapped, and a quantity of benzolized oil is continuously delivered to the still through a vapour-to-oil heat exchanger, and steam heater of the coil type. The debenzolized oil from the still flows by gravity to a rack type cooler, and thence back to the scrubber *via* a small ring filled foul gas scrubber, and the debenzolized oil pump.

The condensate from the heat exchanger is continuously returned to the gas oil in circulation, after automatic separation of the water, so that only one product is made. This arrangement makes for simplicity in design and operation, the entire oil circulation through the plant being controlled by one valve. The extraction efficiency is of the order of 85% of the benzole in the gas.

The above plant as originally designed was of mild steel fabrication with the exception of the cast-iron rack type oil cooler. It very soon became obvious that an alteration was called for, as deliveries of steel plates and sections from the rolling mills lengthened to as much as 15 to 20 weeks. A change-over to cast-iron construction was, therefore, made. This had a further advantage in that standard castings for items such as tower plates could be made and stocked against possible future requirements.

In connexion with these standardized units described, a circular letter enclosing a questionnaire form was sent by some

* Paper to the Scottish Junior Gas Association (Western District), Jan. 18, 1941.

contractors to a large number of the smaller works not at that time extracting benzole. An estimated balance-sheet was then submitted to the undertakings in question, setting out the economics of the process, so as to assist the engineer as far as possible.

At the same time The Institution of Gas Engineers issued a confidential Communication, dealing with the improvization of recovery plant, and the adapting of existing gas scrubbing units for benzole extraction. This communication set out in very clear detail what could be done by gas undertakings themselves to construct recovery plant from existing materials normally found in works stores, standard pipes and fittings, and items such as disused cast-iron gas mains, which would formerly have been classed as scrap material. Full information was given in the publication regarding the dimensions and arrangements of the various components, the oil circulation required, steam and water consumption entailed, and the efficiency of recovery which could be expected from such plants. No doubt all engineers are in possession of this interesting publication, so I do not propose to make further reference to it at this time.

Having dealt with new plants and plants which can be built by the works themselves, the question then arises as to what can be done to increase the efficiency of benzole extraction in existing installations. Due to the necessity of gas undertakings to meet their statutory obligations in respect of calorific value, many benzole plants have been installed in recent years for a designed production of one and a half to two gallons per ton of coal carbonized, representing in most cases a partial recovery of between 50–60%.

As far as the scrubbing plant is concerned, the main factors which determine the amount of benzole removed from the gas are:

1. The oil circulation through the scrubber.
2. The temperature at which the scrubbing is carried out.
3. The surface area of the scrubber filling.
4. The efficiency of contact between the gas and wash oil in the scrubber.

The influence of most of these factors has been very thoroughly investigated in the past, and the results have been expressed on a mathematical basis. It is not within the scope of this Paper to discuss these factors this afternoon. To do so would make the Paper very long, and would be a repetition of work published elsewhere, but particular reference may be made to the Papers which have been given from time to time by Dr. Hollings and members of the technical staff of the Gas Light & Coke Company.

For an extraction of say 50–60% of the available benzole in the gas, an oil circulation of the order of four gallons per 1,000 cu.ft. of gas is normally required. Unfortunately the extraction efficiency for any particular washer is not directly proportional to the oil circulation through it, and to obtain a low slip of 10–15%, about 10 gallons per 1,000 cu.ft. of gas are necessary. The fact that the necessary oil circulation increases rapidly when recoveries of 90% and upwards are attempted sets a limit to the most economical conditions of working of the plant. The oil requires to be heated, steam distilled, and re-cooled during the complete cycle, and the higher the oil throughput, the greater the overall expense of the process in pumping costs, steam, and cooling water.

On many existing plants installed for partial extraction of the benzole in the gas, the design of the various components is such that there is usually about 15–20% margin for overload above rated oil throughput without upsetting the working of the plant, and to take advantage of this and still maintain low operating costs, as much use as possible must be made of heat exchange. In practically all recovery units, large or small, an oil to oil heat exchanger is a standard component, but in many cases the inclusion of an exchanger working on the vapour to oil principle is justified by a saving in steam in the final oil heater amounting to some 10% of the total steam requirements, and by a reduction in the overall water consumption of the plant.

Where a vapour to oil exchanger cannot be fitted in with the existing layout, an additional vessel to the oil to oil type may be included to handle the increased oil throughput, and this has been done in several instances known to the Author. The manufacturers of the plant will give every assistance when such modifications are being considered, and it is recommended that they be consulted in this connexion.

The use of vacuum distillation is a noteworthy advance in the technique of recovery, but it is doubtful if the cost of such a refinement is justified under wartime conditions on medium and small plants of below 5 million cu.ft. per day capacity. It is unfortunately not a very simple matter to adapt vacuum distillation to existing units, the size of the still being generally too small to allow for the increased volume of the distillate vapours at the reduced pressure.

Turning now to the question of the temperature of the debenzolized oil returned to the scrubber, this is of primary importance on account of the change in the vapour pressure of benzene with rise of temperature. This increases fairly uniformly from 46 mm. of mercury at 10° C. to 96 mm. at 25°C. Working with a normal oil rate of say five gallons per 1,000 cu.ft. of gas at a washing temperature of 20°C., the extraction obtained will be of the order of 65% of the benzole in the gas. Under the same conditions, but working at 15°C., the percentage extraction will be some 10% higher. Generally speaking the return oil temperature should be as low as possible, but should not be below the temperature of the gas at the inlet to the washer, so as to avoid condensation of water vapour from the gas by contact with the colder oil. Excessively low oil temperatures should also be avoided, or trouble may be experienced by the thickening of the oil in the cooler tubes.

The oil coolers fitted to many existing recovery plants are of the cast-iron rack type, and should these prove to be on the small side when working at increased oil rates, it is a relatively simple matter to arrange for a further number of pipes to be added, either on top of the existing banks, where conditions of pressure head allow of this, or alternatively, grouped alongside the existing cooler, and to modify the oil and water pipe-lines to suit the new arrangement.

When higher extractions of benzole are aimed at, the supervision and technical control of the plant should receive a little more attention than perhaps has been customary. Most plants built in recent years have been fitted with automatic controls, and at some works provided the benzole make averaged about two gallons per ton, and the calorific value of the gas remained satisfactory, no one worried very much about the working of the plant itself.

While this speaks well for the design, in many cases greater attention would have been well repaid. A typical example of such an instance is to be found in the formation of growths on condenser coils, dephlegmator tubes and cooler pipes. With some types of cooling water this is very rapid, resulting in excessive water consumption, and possible loss of benzole as vapour, due to the reduced heat transfer across the coils or tubes of the final benzole condenser. Where surface water is being used for cooling and the temperature of this runs rather high, as frequently happens in summer time, the use of a small auxiliary supply of town water is probably justified. In this connexion it is always as well to remember that two wrongs do not make one right, and regular inspection of cooling coils or tubes with brushing or descaling where necessary will be amply rewarded.

In the case of a works where town water has to be used for cooling purposes, this can conveniently be carried out in a closed system in conjunction with a cooling frame. This is quite a practical proposition, and the amount of make-up water required to replace losses due to evaporation is small. Where automatic controls of the "Arca" type operated by town water pressure are a part of the equipment, the waste water from these can be run to the cooler sump, so as to reduce make-up losses as far as possible. The formation of growths seems usually to be more prevalent where a re-circulation water system is adopted, but this can be reduced and in some cases prevented by the addition of a small amount of copper sulphate to the cooling water supply. Five parts per million by weight is usually sufficient for this purpose.

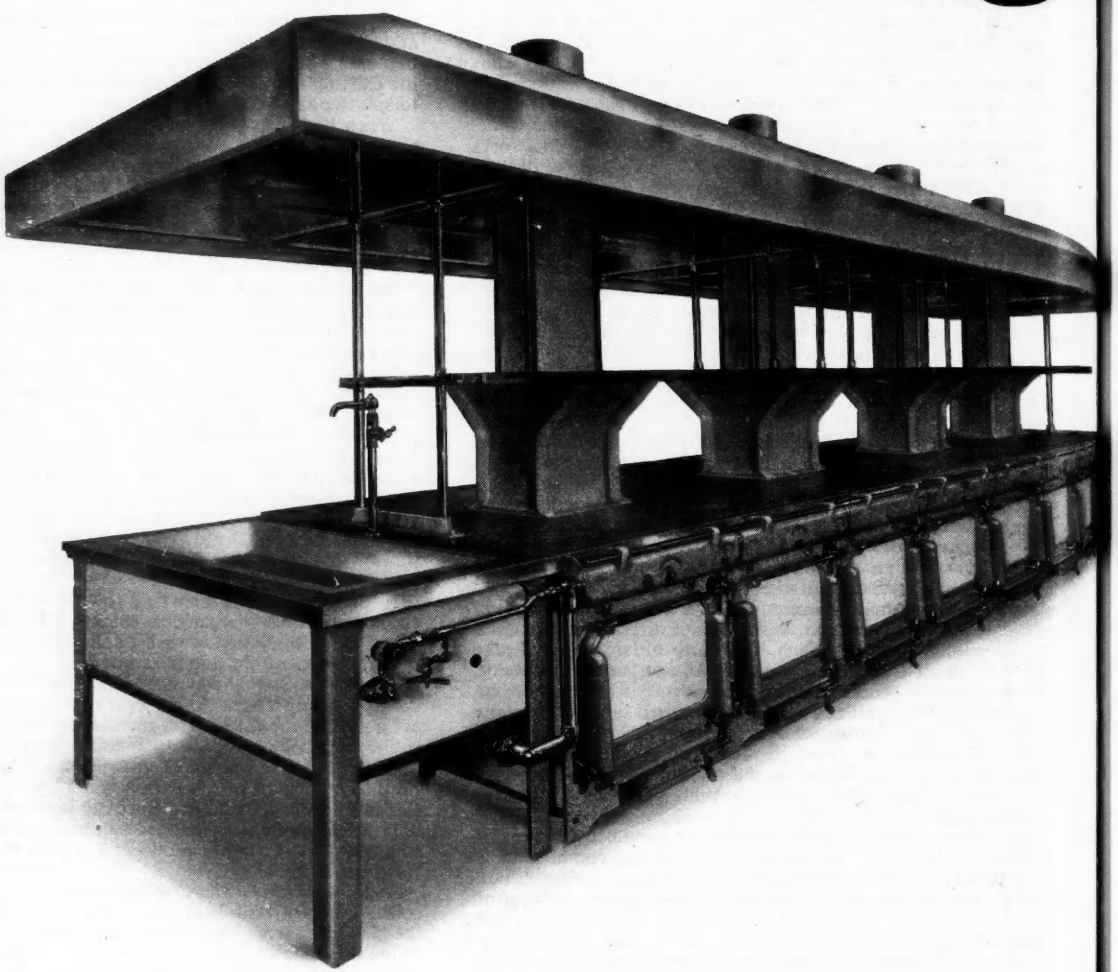
As an alternative where town water is in use, with a view to conservation of both heat and water, it is quite feasible to run the hot water from the various components to a hot well, and to use this as feed water for the boilers. Works layout does not always permit of this, but where possible it is worth consideration.

Evaporation from storage tanks during summer months, though comparatively small, can cause quite an appreciable loss of benzole over a period. Such tanks are often vented to atmosphere, but where practicable it is an advantage to couple up these vents to a small scrubber packed with suitable material, down which the cold debenzolized oil flows on its way from the coolers to the main gas scrubber.

The regular testing of benzolized and debenzolized oil samples, together with an occasional check of the steam consumption of the heater and still, should form a part of the routine supervision of all extraction plants. Steam consumptions can be measured conveniently by collecting the condensate from the steam trap on the heater, and the water overflow from the benzole and naphtha seperators. Debenzolized oil samples may vary slightly, but a typical distillation of a well debenzolized oil is as follows:

120°C.	. . .	0.0% by volume.
140°C.	. . .	0.1% "
160°C.	. . .	0.3% "
180°C.	. . .	0.5% "

Large



A battery of Grosvenor Ranges. Can be supplied in any number of units as required.

Radiation Ltd.

These analyses in conjunction with periodic tests of the benzole content of the gas at inlet and outlet scrubber determined by either the freezing method or alternatively by absorption in wash oil, give the plant operator and technical staff a direct check on the efficiency of the extraction process.

A matter sometimes apt to be overlooked, but worthy of attention, especially if troubles are experienced, is the checking of recording and indicating thermometers. These are usually very reliable, but errors may develop after long use. Thermometer pockets are now usually provided adjacent to the gauge connexion, so that the instruments can be easily checked over.

Log sheets showing a record of temperatures and pressures should also be available, and these should be inspected daily by the technical staff.

So much for what can be done towards increasing the production of benzole. The question then arises as to the effects of this on the utilization of the gas and on the business side of the undertaking. In this connexion it is impossible to be dogmatic and say that benzole extraction is always profitable. So much depends on local conditions, mainly with regard to the prices of coal and coke, and the market which can be found for additional coke produced.

In districts where the coke market is approaching saturation, it is perhaps more logical to consider the question of making a statutory change in the declared calorific value of the undertaking. Removal of benzole, besides being accompanied by a reduction in the calorific value of the gas, also entails a decrease in volume of some 35 to 40 cu.ft. per gallon extracted. The extent of these factors is dependent on the original make per ton and calorific value of the gas, and on the quantity, and to a smaller extent on the quality of benzole produced. In general terms, assuming the same overall thermal output for the undertaking, and making allowance for the reduced calorific value and loss of volume due to benzole extraction, the recovery of three gallons of benzole per ton means that an average increase of approximately 6% in the total volume of gas to be made is required, while a slightly lower percentage has to be stored and distributed. The total amounts of coal to be carbonized and the resulting coke produced are altered accordingly.

The specific gravity of the gas will be slightly reduced, which has an advantageous effect on the costs of supplying the gas to the consumers. The distribution systems of most undertakings carry a reasonable margin for overload, and the question of supplying the extra volume of gas to compensate for the reduced calorific value should not present any great difficulty. In cases where the mains are working to full capacity, a possible alternative is to consider supplying the gas under increased pressure, this being reduced again at suitable points on the district.

Regarding the utilization of gas of reduced calorific value, it has been shown that provided the same number of heat units are supplied in the same time, the calorific value and the composition of the gas can be varied over limits considerably wider than would result from complete extraction of the benzole from the gas, without any appreciable change in the thermal efficiency of the appliance.

This method of dealing with the question of benzole recovery has the undoubted advantage that the working of the retort house is unaltered, except for a slight increase in throughput, which should tend towards a reduction in overall carbonizing costs, and the former efficiency of gas making is maintained. Practical results seem to bear out these considerations, and several undertakings have made a statutory change during recent years. In view of the present national situation it is likely that every encouragement would be given to any such application where benzole recovery was being considered.

Where the decision is taken to maintain the declared calorific value on the district, the calorific value at inlet benzole plant must be raised. In most cases the required increase lies between 8–10 B.Th.U. per cu.ft. for every gallon of benzole extracted per ton of coal carbonized, so that for the production of three gallons per ton, an increase of some 25–30 B.Th.U. per cu.ft. is necessary. While this may be quite feasible on a works with horizontal retorts and carburetted water gas, a different state of affairs exists where the carbonizing plant consists of steamed vertical retorts, and the declared calorific value is in the region of 475–480 B.Th.U. per cu.ft. Assuming that the required increase in calorific value can be attained by reduction in steaming, a resulting loss of gaseous therms per ton of coal carbonized is entailed. At a works making, say, 18,000 cu.ft. per ton of 475 B.Th.U. per cu.ft. gas, the extraction of three gallons benzole per ton of coal requires an increase in the calorific value of the gas, as made, of approximately 23 B.Th.U. per cu.ft. From steaming curves, the thermal loss in this instance, considered from a gas-making point of view only, is of the order of six therms per ton.

This involves an increase in the tonnage of coal to be carbonized, so as to maintain the overall thermal output of the works at its former figure, and also an increase in the total coke produced, due first to the increased coal carbonized, and secondly to the increased coke production per ton of coal, caused by the reduction in steaming, the latter amounting to about $\frac{3}{4}$ cwt. per ton of coal when extracting three gallons of benzole. As a balancing factor there is a saving in steam which approximates fairly closely to the amount used on the benzole plant itself. In general terms the main items which influence the balance-sheet are the difference between the price paid for coal and that obtained for coke, and the state of the coke market.

The effect of the war on the latter has unfortunately been anything but hopeful. A large amount of coke was previously exported from Great Britain to the Continent and Scandinavia, Scotland having quite a considerable share in this market. It is hardly necessary to say where this export business has gone in the present circumstances, and as a result at some works the production of additional coke is looked upon as something to be avoided at all costs.

The gas and fuel industries have in the past always been active in adapting themselves to changing conditions, and new markets are being found to replace those lost due to unforeseen circumstances.

The Government's policy for increasing home-produced agricultural products has opened up new fields in connexion with the drying of grass and grain, in which coke is finding extensive use. The importance of this development will increase as time goes on and the schemes are more extensively adopted. Military establishments such as barracks, aerodromes, &c., form a potential market, and in addition the Government is urging the stocking of coke by merchants and large consumers, against possible winter difficulties and emergency requirements.

Much has been done in recent years to improve the quality of coke produced, and its utilization in special grates and other appliances. In this connexion it may well be that the technical developments concerned have got ahead of the business side of the question, and when looking for increased sales it would pay to carry out development work in connexion with the methods of marketing of coke, as well as its efficient utilization.

Most areas are now served by active coke marketing associations working in close touch with the producers, under which the selling of coke is organized on a co-operative basis, but as far as the Author is aware the position in Scotland in this respect is not yet in line with the rest of the country. Through these organizations the market price of coke is now controlled, and a general rise of prices throughout the country cannot be effected without Government consent.

In districts near the source of coke production—*i.e.*, the lower part of Scotland, the North-East Coast, South Yorkshire, Lancashire, and the Midlands, the market for coke is approaching saturation. The price of coke in these areas is relatively low, while for the most part the standard of wages compares favourably with other parts of the country, particularly under present conditions. In agricultural districts where wages are somewhat lower, coke markets have not yet reached anything like saturation, but in these areas the price of coke is increased by the heavy freightage rates, thus retarding its development in competition with other fuels. With a view to levelling out the distribution of coke it is understood that steps have already been taken to divert coke from districts where there is a surplus to districts where there is a shortage.

In the case of other commodities, many of these are obtainable from stores or shops at prices which vary very little throughout the length and breadth of the country, whether sold near to the manufacturers' works or at a good distance away from it. In effect the goods sold near to the source of production are subsidizing the transport charges on those sold further afield. The manufacturers are virtually selling their goods under a national marketing scheme, but it is a scheme which is of their own making.

Such an idea if applied to the marketing of coke would require the manufacture of standard grades with regard to ash and moisture content, &c., but in principle there does not seem to be anything against the production and marketing of coke to standard specification, in the same way as other products, such as gas, benzole, tars, and sulphate of ammonia are produced and sold.

A general rise in prices need not necessarily be involved. In some areas prices would rise, and in others they would fall, but the reduction would occur in districts where the development of the coke market had been previously held up by the selling

price, and this may go some way towards promoting new coke sales in these areas.

Many potential fields for coke are at the same time fields for gas, and it may well be that in many cases that latter commodity has been put forward in preference to coke, where either could have been used with advantage. In past years the Gas Industry has regarded the production and sale of gas as the only important item in the business, coke being looked upon along with benzole, tar, and ammonia products, as necessary evils to be disposed of as profitably as possible. In the case of coking plants the reverse held good, and gas was the by-product.

The two industries have much in common, yet one is met with the position of gas-works striving after the production of every possible therm as gas, with the coke and other by-products taking their chance as it were, whereas nearby coke ovens are burning surplus gas to atmosphere for the sake of making coke, or at least were doing so before the introduction of the blackout.

Either case means that the utilization of the natural raw material, coal, is not being carried to the best advantage, and it would seem that there is need for a better fuel policy than that existing at present, under which the whole process of carbonization, whether at gas-works or at coking plants, is regarded more as a chemical engineering problem of coal processing, and gas, coke, and chemical by-products are looked upon from the sales angle, as being more on an equal footing than at the present time.

Under such a policy it would seem sound business that the producers themselves should be in control of the development and marketing schemes for their own products. In the carbonization industries, after crude benzole, tar, &c., have been produced, they are sold to other organizations which carry out the refining and subsequent treatment, and which control the marketing of the developments they themselves have made. The important difference between the position of these organizations and the carbonizing industries lies in the fact that their production programme can be regulated to suit their selling programme, so that the two work together.

In the gas and coking industries, such is not the case at the present time, and so far as by-products are concerned, they are dependent on the prices which the development organizations will pay for the crude materials. As these are normally purchased to specification the actual source is not of primary importance, and as a result the fortunes of the by-products industries are in reality out of the hands of the producers.

A practical illustration of this can be seen by a comparison of the position in the coal and oil industries. Both produce a naturally occurring fuel from the earth ; in one case it is in solid form, in the other it is liquid, but there is no fundamental difference between the two. Both fuels are the source of very many valuable by-products, but those in control of the oil industry were not content to regard themselves simply as producers of crude oil to be sold at a price sufficient to cover the working costs of obtaining it from the earth plus a reasonable profit. They took in hand the development of their own refining industry, and this, together with the marketing of the products their research work had given them, remained under their own control. Such an organization must be better equipped to deal with fluctuating marketing conditions than one producing an unfinished product, and depending on a second industry for its sale.

Under the outlook of the coal-mining industry in past years one of the most valuable of the nation's natural assets has been sold to the highest bidder for the sake of financial interests. A large proportion has been burnt, and much of its intrinsic value wasted, instead of being processed in such a way that the best use was made of the various products which could have been obtained from it. Even in present circumstances, when it is surely of the utmost importance that the maximum use is made of all our resources, large sums of money are being expended on publicity campaigns and the like to encourage the public in the burning of coal in the raw state for domestic purposes. It would seem that from a national standpoint, much good could be done by more active co-operation between the coal-mining interests of the country and the gas and coking industries, each assisting the other as partners in the fuel market.

Views on this subject are slowly developing, and no doubt the influence of the present emergency will be to bring them into prominence, in a shorter time than would have been possible under conditions of peace. It seems a great pity that this should have to be necessary, but if such a change does come about, the carbonization industries will have a large part to play in it, and it is possible that the future may see the engineer and technician come more into their own rights in this connexion.

A few final words regarding the installation of further recovery plant with a view to obtaining the benzole still remaining as a potential possibility in this country at the present time. The Advisory Committee have given careful consideration to the question as to whether any compulsory action was required, and concluded that it might be expected that undertakings would be ready to offer their full co-operation of their own accord, without any such action being necessary. It is not suggested that any pressure might be brought to bear in the future, and the matter remains in the hands of the undertakings themselves. In past years no doubt all gas engineers will have examined the question of benzole recovery as applied to their own works, and will have reviewed this since the outbreak of war. The matter may have been deferred because the economics were such that while a profit could be shown under the present emergency, a different state of affairs may obtain after the war.

It should not be forgotten, however, that the Government assistance to home-produced fuels representing a further guarantee of a preference of 8d. per gallon will remain in force for ten more years, and is a valuable subsidy towards the economics of benzole recovery. There are very few cases where the installation of a benzole plant does not show a good return of capital invested, and the installation does not end up by being merely a wartime emergency plant. The undertaking which installs a recovery plant is in the ordinary way providing a money-making accessory, and at the present time it is assisting greatly in the war effort not only in spreading the supply of motor spirit, but in producing a very valuable war commodity in the shape of toluene.

In conclusion, the Author's best thanks are due to the Advisory Committee on Benzole Recovery for permission to refer to a part of their work, and to the management of Messrs. Newton, Chambers & Co., Ltd., for the facilities afforded. It is hoped that the Paper will have been of interest to members in giving some views from outside the industry itself, and the Author is very happy to have been able to refer to practical results of the close co-operation which has always existed between the Gas and contracting Industries, and to express the hope that this will continue for the future.

More Coke Sold in Toronto

In their report for the year ended Sept. 30 last, the Directors of the Consumers' Gas Company of Toronto state that the financial results show unmistakably the effect of a number of adverse factors brought about by the war, but, notwithstanding the unusual conditions which have prevailed, the output of gas has been well maintained, while the quantity of coke sold was 35% greater than in the preceding twelve months. The gross operating revenue for the year amounted to $7,271,118, and exceeded by $124,136, the sum required to meet operating expenses, taxes, actual repairs and renewals, and the regular dividend. Increases in the cost of coal and of other necessary materials, the higher rates paid for labour, and greatly increased taxation added materially to the operating costs. This additional expenditure is principally of an uncontrollable class, and is related directly to Canada's war effort. For every dollar received for the sale of gas, 12.2 cents were paid to the taxing authorities. The corresponding figures for 1930 and 1920 were 7.2 cents and 4.8 cents respectively. The full effect of further taxation resulting from the Dominion Budget presented last June will not be shown until the presentation of the next accounts. Over the past two years a great deal of study has been given to the sales organization, with the object of improving the quality of the Company's sales effort.

Measurement of High Vacua

A long-felt need for an inexpensive vacuum gauge covering a useful range of low pressures and at the same time simple to operate has been met by the development of the " Vacustat " by W. Edwards & Co. (London), Ltd., Southwell Road, London, S.E. 5. It is a modification of the well-known McLeod gauge and, while similar in principle, it differs considerably from the usual forms of the gauge, both in construction and methods of use. The " Vacustat " measures only 9 in. high, and this fact, together with the small quantity of mercury needed, makes the gauge really portable. The need for raising the mercury level to compress the gas is obviated by making the " Vacustat " of such a form that rotation about its centre causes the compression and is the only operation necessary to take a reading. A clear direct reading scale covers the range from 10 mm. to 0.01 mm.

New Gas Blow Torch

A new self-acting gas-heated blow torch has been introduced by Runbaken Electrical Products, 71–73*a*, Oxford Road, Manchester. Light brazing, soldering, tempering and hardening can be carried out by making a simple connection to the nearest gas supply. No compressed air is required, and the intensity of the flame is adjustable.

INSTITUTION OF GAS ENGINEERS

AN INVESTIGATION INTO A RAPID METHOD OF ASSESSING THE RESISTANCE OF REFRACTORY MATERIALS TO DISINTEGRATION BY CARBON MONOXIDE*

By F. H. CLEWS, M.Sc., A.I.C., H. M. RICHARDSON, B.Sc., A.I.C., N. E. DOBBINS, M.Sc., and G. R. RIGBY, Ph.D., B.Sc., A.R.C.S., D.I.C., A.I.C.

THE disintegrating action of carbon monoxide on certain types of firebrick at temperatures between 350° and 650°C. is well known as an important cause of failure of refractories in plants where exposure to carbon monoxide in this range of temperature is involved. A convenient and rapid method for assessing the resistance of firebrick materials to the disrupting influence of this gas would therefore be of immediate service as a guide to the selection of refractories for duty in such installations.

The method hitherto employed has consisted in exposing selected pieces of the refractory to the action of carbon monoxide at 450° or 500°C. and observing their behaviour. The test has to be continued for prolonged periods since with some materials no alteration of the test-pieces is apparent until a considerable time has elapsed. With resistant materials it is customary to expose the specimens to the carbon monoxide for 200 hr., before concluding the test. Even when specimens have successfully survived this treatment there is still a doubt whether further exposure would not have produced breakdown. The extended time required to carry out a test of this kind is a distinct drawback. K. Pukall has suggested a procedure in which in effect the permeability of a specimen to carbon monoxide at 500°C. is measured. In practice the test has proved difficult to apply because deposited carbon first reduces the permeability before incipient fracture increases it.

It is well known that the mechanism of the disintegrating action is the growth of carbon formed by the reaction $2CO \rightarrow C + CO_2$, which occurs preferentially at the " iron spots." For disintegration to occur it is necessary that the " iron spots " should be reactive to the carbon monoxide. Recent work points to the real catalyst being metallic iron, produced by the reducing action of the carbon monoxide on the iron oxide of the spot. Inasmuch as carbon dioxide is always produced when firebricks are broken down by the action of carbon monoxide and since even the strongest bricks seem unable to resist the large mechanical forces accompanying the deposition of carbon once the growth has started, it was considered that the measurement of the carbon dioxide formed on leading carbon monoxide over the refractory might form a reasonable basis for a test for resistance to that gas. In order to render the test more sensitive and rapid a relatively large sample in powdered form was envisaged.

The carbon monoxide was prepared from formic acid and sulphuric acid and stored overnight in a gas-holder containing alkaline pyrogallol. It was displaced from the gas-holder by a steady flow of water from a constant head. The displaced gas was further purified from oxygen and carbon monoxide by passing through a long vertical tube filled with grog kept moistened with alkaline pyrogallol. The gas was next dried by passage through tubes of soda lime and calcium chloride, and was finally bubbled through a bottle containing concentrated sulphuric acid, after which it passed to the reaction tube. The horizontal reaction tube was of fused silica 1 in. in diameter and about 2 ft. in length. The central portion was heated electrically and there was a zone, 6 in. long, which was nearly uniform in temperature. The sample was prepared from half a brick which was completely crushed to -4 mesh and then reduced by quartering to about 100 g. After drying, exactly 100 g. were weighed out and introduced into the silica tube, being kept in the zone of uniform temperature by asbestos plugs. After traversing the silica reaction tube the gas either passed through two absorption bottles containing sofnalite and calcium chloride or was by-passed to waste. In carrying out a test, the air in the apparatus was first swept out by a rapid stream of nitrogen from a gas-holder containing alkaline pyrogallol. The carbon monoxide was then passed over the specimen while the temperature was being raised to the required value. It was arranged that the gas did not flow through the absorption bottles until the specimen had reached the desired temperature. When this occurred the absorption bottles were included in the circuit and weighed, usually after intervals of an hour.

* From Communication No. 2 of the Gas Research Board.

Magnitude of the Reaction

In order to test the sensitivity of the method a series of experiments was carried out at different temperatures with a firebrick material known to be attacked by carbon monoxide and at the other extreme with a silica brick which might be expected to be inert. The results obtained are given in Table I. Comparison of the results obtained for the two types of brick indicates that the purely thermal decomposition of carbon monoxide into carbon dioxide and carbon was almost negligible in comparison with the catalytic decomposition by the iron spots of the firebrick at about 500°C. The contrast in the two sets of results provided good grounds for the hope that the method might prove satisfactory as a means of testing resistance to carbon monoxide attack.

Unfortunately it was found difficult to duplicate the results on a particular firebrick. Sometimes considerable attack occurred,

TABLE I.—CARBON DIOXIDE FORMED ON PASSING DRY CARBON MONOXIDE AT AN APPROXIMATE RATE OF 1½ LITRES PER HR. OVER 100 G. OF (i) CRUSHED SILICA BRICK, AND (ii) FIREBRICK.

Temperature, °C.	Increase in Weight of Absorption Bottles during—			
	1st hr.	2nd hr.	3rd hr.	4th hr.
1	2	3	4	5
Silica Brick				
500	0.0039	0.0046	0.0054	0.0039
450	0.0047	0.0047	0.0038	0.0047
400	0.0022	0.0030	0.0036	0.0035
350	0.0031	0.0031	0.0058	0.0044
Firebrick				
525	0.3208	0.5890	0.4744	0.3776
500	0.4768	0.4136	0.6047	0.7379
470	0.2585	0.3869	0.4186	0.4415
450	0.0831	0.0533	—	—
350	0.0018	0.0041	—	—

giving both large quantities of carbon dioxide and considerable deposits of carbon among the brick specimen, and at other times there was little or no evidence of any reaction under conditions of experiment that were as identical as possible. After investigating the adequacy of the sampling procedure it was discovered that the use of the sulphuric acid drying bottle immediately preceding the reaction tube was responsible for the discrepancies in the results.

At this period of the investigation the necessity or, indeed, the desirability of drying the carbon monoxide was considered. The results given in Table II indicate that the reaction giving rise to carbon and carbon dioxide proceeds more rapidly in the presence of a small quantity of moisture.

In developing the test further, the use of a drying train was therefore abandoned and a bubbler containing water was substituted for that previously containing sulphuric acid.

Standardized Procedure

The procedure finally standardized for investigating the efficacy of the method was identical with that already described except in the following details :

(*a*) Half of a standard sized brick or a lump of similar size from a large shape was crushed until it passed completely an 8 sieve, and this crushed sample was reduced by quartering to about 80 g. from which 75 g. were weighed out for the test. It was thought that this increased subdivision of the brick would improve the representative character of the sample and increase its rate of reaction. The zone of uniform temperature in the reaction tube was occupied by 75 g. (*b*) The reaction temperature was fixed at 450°C. At higher temperatures it had been noticed that there was a slight tendency for uniform deposition of carbon as distinct from that causing disintegration by growth around iron spots. (*c*) The carbon monoxide, stored during the night over alkaline pyrogallol, was passed over grog soaked in the same reagent and then through a bottle containing water

TABLE II.—Carbon Dioxide Produced on Passing Carbon Monoxide at 1.5 litres per hr. under Different Conditions over Similar 75 g. Samples of (−30+80) Firebrick at 470°C.

Condition of Carbon Monoxide.	Increase in Weight of Absorption Bottles during—				
	1st hr.	2nd hr.	3rd hr.	4th hr.	5th hr.
1	2	3	4	5	6
Dried by $CaCl_2$	0.5736	0.5716	0.4880	—	—
Dried by P_2O_5	0.4049	—	0.6536	—	0.6159
Dried by H_2SO_4	0.6680	0.8131	0.6976	0.6833	0.5706
Saturated with H_2O at room temperature ...	0.6089	1.4041	1.1888	0.8238	0.8888

at room temperature at the rate of 1 litre per hr. (*d*) A drying tube containing calcium chloride was interposed between the exit of the reaction tube and the sofnalite absorption bottles.

This procedure was applied to a number of firebrick materials for which data were available on the behaviour of cylindrical specimens 1.25 in. in height by 0.75 in. in diameter, in a current of dry carbon monoxide at 450°C. for periods extending up to 200 hr. The results obtained are set out in Table III.

Inspection of the table reveals that considerable amounts of carbon dioxide were produced in the 4-hr. test period with those materials which suffered disintegration in less than 50 hr. in the dry gas, according to the old procedure. On the other hand, for those materials which were not disintegrated after treatment for 100 or 200 hr. with carbon monoxide the carbon dioxide produced in 4 hr. of the " rapid test " was quite small. Following the standardized procedure previously described it would appear that materials are definitely prone to disintegrate if more than 0.1 g. CO_2 is produced in the 4-hr. test period immediately succeeding the first half hour at 450°C. In support of this statement is the fact that carbon spots were unmistakably present only in the crushed brick samples which yielded quantities of carbon dioxide in excess of this amount. Similarly those materials which yield less than 0.05 g. in the same period would appear to be able to resist the action of carbon monoxide. The materials which yield intermediate quantities of CO_2 in the test period are open to suspicion. It would probably be difficult to classify such products in any test whether rapid or prolonged.

The three sets of results 11(*b*), (*c*) and (*d*) refer to duplicate tests on 75 g. portions obtained by quartering from the same sample of a crushed half brick. There is seen to be better agreement for the total carbon dioxide produced in the 4-hr. test period than for the rate per hour at different periods of the test. The test on 11(*a*) was carried out at a rate of flow of carbon monoxide of 2 litres instead of the standard 1 litre per hr. The result though greater is not very much in excess of those for 11(*b*), (*c*) and (*d*), but the difference is sufficient to emphasize the necessity of adopting a standard rate of flow of carbon monoxide. With bricks that are less reactive than No. 11, the rate of flow will probably be of less moment.

Although the duplication of results for brick 11 was not very close, the limited number of centres giving rise to carbon growths should be borne in mind. It will then be realized that the differences can be ascribed almost entirely to difficulties of sampling. The duplicate results for brick 6 provide an illustration. Sample 6 (*a*) yielded 0.08 g. CO_2, but did not develop any obvious carbon spot; sample 6 (*b*) yielded 0.16 g. CO_2 and developed two small carbon spots; sample 6 (*c*) yielded 0.14 g. CO_2 and developed only one carbon spot. Out of the 75 g. of each sample the potentially reactive portion is thus concentrated in a very few grains, each of extremely small weight and size. The likelihood that each successive sample from a brick of this nature will contain the same number of active centres is remote. Nevertheless, the method of crushing and quartering would seem to be an improvement in sampling procedure on that hitherto adopted in which specimens are merely taken haphazard from the exterior and interior portions of the brick.

Conclusions

It is felt that a satisfactory rapid test for assessing the resistance of refractory materials to the action of carbon monoxide has been developed on the basis of the foregoing experiments. It is suggested that :

(i) In preparing a test sample, at least half a brick is crushed (avoiding metallic iron contamination) to pass an 8 sieve. The sample is obtained by quartering and 75 g. is a suitable weight.

(ii) The sample is placed in a fused silica tube of at least 1 in. bore and heated for 4½ hr. at 450°C. in a stream of moist carbon monoxide freed from oxygen and carbon dioxide at a rate of 1 litre per hr. Before raising the temperature to 450°C. it is necessary to remove the residual air from the tube and sample by a rapid stream of nitrogen followed by one of carbon monoxide while the temperature is rising.

(iii) The increase in weight of the sofnalite absorption bottles, during the 4-hr. period commencing 30 minutes after 450°C. is reached, is measured. Materials which yield more than 0.1 g. of carbon dioxide per 75 g. sample—*i.e.*, 0.13% of the weight of the sample—may be considered non-resistant to the action of the gas. If less than 0.05 g. of carbon dioxide per 75 g. sample is formed the material may be considered resistant. If between 0.1 and 0.05 g. carbon dioxide per 75 g. sample is formed it would be preferable to repeat the test, and to regard material as resistant to the action of the gas if in three successive tests less than 0.1 g. of carbon dioxide were produced.

(iv) The crushed brick sample is examined when cold for carbon deposition. Any obvious lack of accord between the results for weight of carbon dioxide formed and the amount of carbon deposited indicates the need for a repetition of the test.

TABLE III.—Action of Carbon Monoxide at 450° C.

Brick No.	A. On 75 g. Crushed Brick.						B. On Cylindrical Specimens.
	G. Carbon Dioxide produced per hr. during :				Total CO_2 produced during whole period excluding first ½ hr.	Carbon Deposits.	
	First ½ hr.	Next 2 hr.	Next hr.	Next hr.			
1	2	3	4	5	6	7	8
Blank (fused silica)	0.0076	0.0043	0.0057	0.0057	0.0200	None	—
1	0.0130	0.0073	0.0071	0.0110	0.0327	None	No visible effects,except a slight alteration in colour, after 200 hr.
2	0.0070	0.0090	0.0092	0.0102	0.0374	None	Only a very slight colour change after 200 hr.
3	0.0106	0.0088	0.0112	0.0120	0.0408	None	Surface darkening after 29½ hr. No further effect after 50 hr.
4	0.0080	0.0197	0.0207	0.0220	0.0821	None	Some darkening but no disintegration after 100 hr.
5	0.0122	0.0145	0.0213	0.0236	0.0739	None	Surface darkening but no other effect after 50 hr.
6 (*a*)	0.0133	0.0211	0.0215	0.0206	0.0843	None	One specimen cracked after 86 hr., and one flaked after 100 hr.
6 (*b*)	0.0136	0.0408	0.0416	0.0372	0.1604	2 small spots	
6 (*c*)	0.0142	0.0344	0.0355	0.0378	0.1421	1 spot	
7	0.0130	0.0168	0.0168	0.0172	0.0676	None	Only a slight colour change after 200 hr.
8	0.1497	0.2318	0.1549	0.1567	0.7752	Some large spots	Two specimens disintegrated after 12 and 24 hr. respectively.
9 (outside portion)	0.0148	0.0170	0.0568	0.0567	0.1475	A few very small spots	No effect after 50 hr.
9 (inside portion)	0.0816	0.4284	0.4437	0.3653	1.6458	Some large spots	Complete disintegration in 7¼ hr.
10	0.3532	0.5902	0.5438	0.5588	2.2430	Large spots	Two specimens disintegrated after 7¼ and 19 hr. respectively.
11 (*a*)	0.0266	0.8125	0.6494	0.2843	2.5587	Some very large spots	Two specimens disintegrated after 6 and 12 hr. respectively.
(*b*)	0.0438	0.5290	0.6021	0.5462	2.2063		
(*c*)	0.0878	0.5402	0.4001	0.4531	1.9336		
(*d*)	0.0390	0.4508	0.4147	0.4974	1.8137		

THE HYDRAULIC SEAL IN GASHOLDER CUPS

A Paper to The Institution of Gas Engineers

[Communication No. 236]

(*Continued from p. 119*)

Let A_5, B_5, C_5, T_5 and H_5 represent the positions of the water levels in the various compartments of the cup and tank for the fifth critical stage. The nomenclature (A_4A_5), (B_4B_5), (C_4C_5) (T_4T_5) and (H_4H_5) indicates the distances moved by the respective water levels between the fourth and fifth critical stages. Now the water level in compartment T will fall by an amount represented by the expression:

$$(T_4T_5) = p_h - f' \quad \text{.....(25)}$$

Also $$(A_4A_5) = \frac{b(B_4B_5)}{a} \quad \text{.....(26)}$$

and

$$(B_4B_5) + \frac{b(B_4B_5)}{a} = p_h - f' \quad \text{.....(27)}$$

The values of p_h and f' are known, so that the magnitude of (B_4B_5) may be readily determined from equation (27). On substituting this value of (B_4B_5) in equation (26), the magnitude of (A_4A_5) is also ascertained. The position of the water level in compartment H will remain the same as for the previous critical stage, so that $(H_4H_5)=0$. Water levels A_5, B_5, C_5, T_5 and H_5 may now be indicated, as shown in Figure 12.

If the fourth critical stage does not obtain and critical stage (V) follows on critical stage (III), then the positions of the water levels A_5, B_5, C_5, T_5 and H_5 may be determined as follows:

Let (A_3A_5), (B_3B_5), (C_3C_5), (T_3T_5) and (H_3H_5) represent the vertical distances which the water levels in the various compartments of the cup and tank will move from their previous positions A_3, B_3, C_3, T_3 and H_3. In this case the water levels in compartments A and C will fall, while the water level in compartment B rises. The water level in compartment T will fall by an amount represented by the expression

$$(T_3T_5) = p_h \quad \text{.....(28)}$$

Then

$$(A_3A_5) + (B_3B_5) + (C_3C_5) = p_h \quad \text{.....(29)}$$

Now

$$(A_3A_5) = \frac{b(B_3B_5)}{a} \quad \text{.....(30)}$$

and

$$(C_3C_5) = \frac{b(B_3B_5)}{c} \quad \text{.....(31)}$$

Therefore

$$\frac{b(B_3B_5)}{a} + (B_3B_5) + \frac{b(B_3B_5)}{c} = p_h \quad \text{.....(32)}$$

As the value of p_h is known, the distance (B_3B_5) may be ascertained from equation (32). The subsequent values of (A_3A_5) and (C_3C_5) are also readily determined from equations (30) and (31). The position of the water level in compartment H will remain the same as for the previous critical stage, so that $(H_3H_5) = 0$. Water levels A_5, B_5, C_5, T_5 and H_5 may now be indicated as shown in Figure 13.

Sixth Critical Stage (VI)

When a lift is landed on the rest blocks and the pressure of gas inside the holder has fallen by an amount equal to the pressure thrown by the lift, uncupping then takes place. The top edge of the cup plate disengages with the blocks on the underside of the dip channel and the cup descends further into the tank water. This movement of the cup is accompanied by a reduction in pressure of the trapped gas contained in the dip and consequently the level of the water in compartment C rises. The water level in compartment A now falls rapidly on account of the fact that while the water is being carried down with the cup, there is also a gradual diminution in the pressure of the trapped gas contained in the dip. The water level in compartment B will also fall as the cup descends.

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To determine the position of the cup at which the trapped gas in the dip is about to "blow", it is necessary to consider the relationship existing between the quantity of water in the cup and the pressure of the trapped gas in the dip. Let A_6, B_6, C_6, T_6 and H_6 represent the positions of the water levels in the various compartments of the cup and tank for the sixth critical stage. The terms (A_5A_6), (B_5B_6), (C_5C_6), (T_5T_6) and (H_5H_6) indicate the vertical distances moved by the respective water levels between the fifth and sixth critical stages. When the sixth critical stage is reached and "blowing" of the trapped gas in the dip is about to take place, it is obvious that the water in compartment B will have fallen until it is level with the bottom of the dip plate. The level B_6 may therefore be drawn in position as shown in Figures 12 or 13. The fall in water levels (B_5B_6) is therefore given. The water levels in compartments T and H remain unchanged, so that $(T_5T_6) = 0$ and $(H_5H_6) = 0$.

Now the sectional area of the water contained in the cup remains constant until flooding of the cup with water from compartment C takes place. Until this flooding occurs, therefore, the sectional area of the water in the cup may be represented by the expression:

$$S = b(B_5B_6) + a(B_5B_6) + a(A_5B_5) \quad \text{.....(33)}$$

where S = the sectional area of the water in the cup in sq. in. As the sectional area of the trapped gas contained in the dip also remains constant from the fifth to the sixth critical stage, then:

$$c(C_5C_6) = b(B_5B_6)$$

and $$(C_5C_6) = \frac{b(B_5B_6)}{c} \quad \text{.....(34)}$$

Also $$(A_6B_6) = (T_5C_6) \quad \text{.....(35)}$$

The value (T_5C_6) may be determined from measurement after locating the water level C_6 from equation (34).

Now the relationship between the distance the cup will descend from the fifth critical stage to the sixth critical stage and the terms S and (A_6B_6) may be stated as follows:

$$F_1(a+b) = S - a(A_6B_6)$$

where F_1 = the distance the cup will descend from its position at the fifth critical stage until the sixth critical stage is reached.

On equating for F_1 the above expression may be stated thus:

$$F_1 = \frac{S - a(A_6B_6)}{a + b} \quad \text{.....(36)}$$

The position of the cup at the sixth critical stage may be indicated as shown by dotted lines in Figures 12 and 13.

All the water levels for the sixth critical stage are now determined and these are shown in Figures 12 and 13.

Attention has already been drawn to the fact that two sets of diagrams are required when investigating the various critical stages; one for the highest positions of the water levels in the tank, and the other for the lowest positions of the water levels in the tank. When the positions of the water levels for the various critical stages have been indicated on the scaled drawings of the effective cup and dip sections, the question of flooding holes may then be considered.

VIII POSITION OF FLOODING HOLES AND CURTAILMENT OF CUP PLATES

It has been shown that at the sixth critical stage a cup will have descended a distance F_1. If this distance is insufficient to bring the lip of the cup below the level of the water C_6, then it is clear that the cup will "blow" during the uncupping operation. From the example of the effective cup section given in Figure 12 it will be seen that the lip of the cup is below the water level C_6, and this indicates that the cup will be flooded with water from compartment C before the critical position is reached; therefore "blowing" of the cup will not take place.

It should be noted, however, that in actual practice the lip of the cup should be slightly below the water level C_6 in order to ensure that adequate flooding of the descending cup takes place before the critical position is reached. On reference to the example given in Figure 13 it will be noticed that the lip of the cup is some distance above the water level C_6, which indicates that "blowing" of the cup will take place as the floating lift continues to submerge in the tank water, after reaching the sixth critical stage. If X = the distance from the lip of the cup to the water level C_6 at the sixth critical stage, then it is evident that flooding holes will be required in the cup plate at a position slightly greater than distance X from the lip of the cup. If a margin of one inch is allowed against "blowing" of the trapped gas beneath the dip plate, then the downward movement of the cup will be reduced from F_1 to $F_1 - F_1/(B_5B_6)$. To the distance X must then be added the value of $F_1/(B_5B_6)$ and also a proportionate amount from the difference in water level (C_5C_6). When a margin of one inch is allowed against "blowing", the water level C_6 will only have risen a distance of $(C_5C_6)\left[\frac{\{(B_5B_6)-1\}}{(B_5B_6)}\right]$ in. from its previous level C_5. Therefore, the proportionate amount to be added to the distance X will be

$$(C_5C_6) - (C_5C_6)\left[\frac{\{(B_5B_6)-1\}}{(B_5B_6)}\right]$$

$$= (C_5C_6) - (C_5C_6) + \frac{(C_5C_6)}{(B_5B_6)} = \frac{b}{c}$$

The distance X_1 from the lip of the cup to the lower edge of the flooding holes may now be stated as follows:

$$X_1 = X + \frac{F_1}{(B_5B_6)} + \frac{b}{c} \quad \text{.....(37)}$$

The method of investigation as described above may be used in determining the extent to which the cup plating of any lift can be curtailed. The curtailment of cup plating and the position of flooding holes is practically identical so far as the mathematical investigation is concerned, and the relationship existing between the two cases is demonstrated in Figure 14.

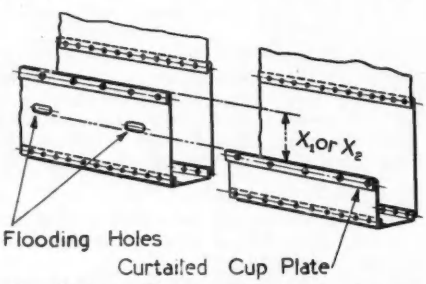

FIGURE 14.—*Diagram Showing Relationship between Position of Flooding Holes and Curtailment of Cup Plating.*

The dimension X_1 represents the highest position in which flooding holes may be placed in the cup plating, or the minimum extent by which cup plating may be curtailed in order to prevent "blowing" during the uncupping operation. The levels of the water in the tank T_1 and H_1 are in this case taken at their highest possible positions as determined from the values of q_t and q_h in equations (3f) and (3g).

It will be appreciated that the sooner flooding of the cups takes place during the process of uncupping, the greater will be the margin of safety against "blowing". The lowest position at which flooding holes may be placed in any cup, or, alternatively, the greatest amount by which the cup plates may be curtailed, is dependent upon the lowest possible level of water in the tank. In these circumstances the cups will pick up the minimum amount of water from the tank as the lifts are inflated and care must be taken to ensure that sufficient water is picked up by the rising cups to provide adequate seals when the holder is fully inflated. The lowest position of the water level in the tank (T_1) and inside any floating lift (H_1) for the first critical stage of a descending cup, may be obtained from the values of q_t and q_h in equations (3d) and (3e), respectively. When preparing the diagrams of the water levels in the cups and dips for the lowest possible position of the water in the tank, the distance e or $(e + e_1)$ from the point of dip overflow to the water level A_1 must be decreased by 1 in. This modification is necessary as no allowance is required for evaporation when considering the amount of water accommodated by the cups as they emerge from the tank. After determining the various critical stages for each cup in a similar manner to that previously described, it is necessary to investigate the position of the cup at a stage where the water in the dip compartments B and C is at the same level. This stage will be considered as a seventh critical stage. It is only necessary to indicate the water levels and position of each cup for the seventh critical stage on the diagrams which have been prepared for the lowest possible levels of the tank water.

SEVENTH CRITICAL STAGE (VII)

On observing the movements of the water levels in the dip compartments B and C between the critical stages (V) and (VI), it will be seen that as the water level in compartment B falls, the water level in compartment C rises, and a point is eventually reached when the water in these compartments is at the same level. At this stage the water in compartment A will have fallen until it is level with the water in the tank compartment T. These positions of the water will be considered for convenience of notation as representing the seventh critical stage and may therefore be indicated in their respective compartments by the terms A_7, B_7, C_7, T_7 and H_7. The positions of the water levels B_7 and C_7 may now be determined from the following relationship:

$$(B_5B_7) + (C_5C_7) = (B_5C_5) \quad \text{.....(38)}$$

where the nomenclature (B_5B_7), (C_5C_7) and (B_5C_5) represents the vertical distances moved by the water levels either in or between the compartments to which the letters refer.

Now $$(C_5C_7) = \frac{b(B_5B_7)}{c} \quad \text{.....(39)}$$

Therefore

$$(B_5B_7) + \frac{b(B_5B_7)}{c} = (B_5C_5) \quad \text{.....(40)}$$

The value of (B_5C_5) may be ascertained by measurement from the diagram of the water levels in the cup for the fifth critical stage, or by direct calculation from the algebraic summation of the distances between the water levels in compartments B and C from the first critical position. A typical example of an effective cup and dip section is given in Figure 15, in which the water levels for the seventh critical stage are indicated in their respective positions.

It will be observed that the level of the water A_7 is in line with the level T_7 and that T_7 will remain in the same position as T_6; also that the water level H_7 will remain at the same level as H_6. The positions of the water levels B_7 and C_7 are, of course, determined from equations (40) and (39) respectively.

Let F_2 represent the distance the cup will descend from its previous position at the fifth critical stage to the seventh critical stage as shown in Figure 15.

Then $$F_2 = \frac{F_1(B_5B_7)}{(B_5B_6)} \quad \text{.....(41)}$$

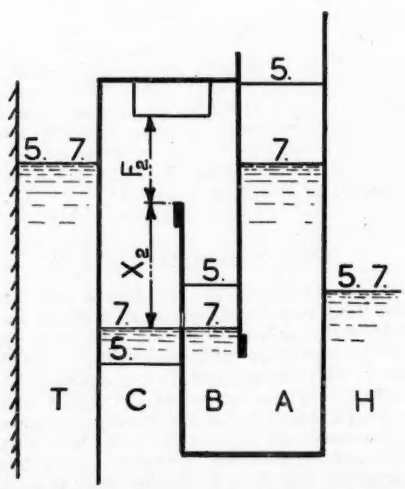

FIGURE 15.—*Diagram Showing Positions of the Water Levels for Critical Stages* (V) *and* (VII); *also Relative Position of cup and dip at the seventh critical stage.*

The greatest distance X_2 from the lip of the cup to the lower edge of the flooding holes, or the maximum amount by which the cup plate may be curtailed, is obtained from the diagram by measurement (see Figure 15), or by calculation from the various water level positions from the first critical stage. There is no necessity in this case to make any allowance in order to ensure that the cup is adequately flooded during its submergence in the tank water, as flooding of the cup compartment B will take place during the time the cup is descending from its position distance F_2 to the position distance F_1 from the dip blocks. The size and number of the flooding holes, when used, however, should be such as will ensure the cup being adequately flooded as it submerges in the tank water. It will be remembered that the foregoing investigations concerning the positions of flooding holes and curtailment of cup plating have been carried out on the effective sections of the cups and dips after taking into consideration the possibility of the lifts being out of level. When deciding upon the actual positions of the flooding holes or the extent of curtailment of the cup plating in the true or original sections of the cups, the distances X_1 and X_2 as determined for the effective cup and dip sections will remain, but these dimensions will be taken from the relatively higher positions of the rest blocks on the underside of the dip channels.

This investigation shows the manner in which the highest and lowest limiting positions for the flooding holes in the cup plates of any lift may be determined, or the extent to which cup plating may be curtailed. In a number of instances the position of the flooding holes, or the curtailment of cup plating, is arranged so that the cups will flood as soon as possible during the uncupping operation, but in some cases certain restrictions with regard to overflow water from the cups require to be imposed on account of oil filming and the storage of dry gas. These restrictions and their effect on the design of cups and dips will now be considered.

IX THE EFFECT OF OIL FILMING ON CUP DESIGN

Oil filming on the exposed surface of the water in the cups and tank of a holder is generally carried out for the purpose of preserving the side sheeting and plating of the lifts from the ravages of corrosion. The plating of the cups and dips, and the top tier of tank side plating, are particularly susceptible to oxidation on the wind and water line. An oil film on the surface of the water in the cups and tank must therefore be retained under all conditions of working if it is to prove satisfactory. Arrangements may be made when designing new holders or when deciding the position of flooding holes in the cups of existing holders, for any surplus rain water or condensate from anti-freezing apparatus to be drained away from the cup inside the holder as shown in Figure 16(a).

If the surplus water in the cups is allowed to drain away via the flooding holes in the cup plates, or, alternatively, over the lip of the curtailed cup plates, the oil film in the exposed portion of the cups will be maintained. The lowest position

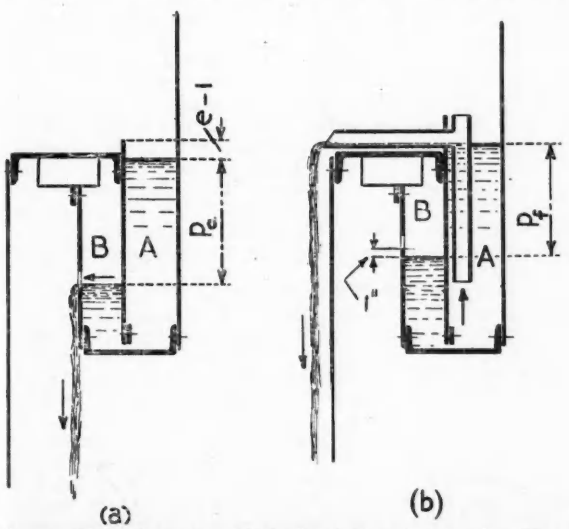

FIGURE 16.—*Alternative Methods of Draining Surplus Water from the Cups of Inflated Lifts.*

of the flooding holes or the maximum curtailment of the cup plating, as determined from the value of X_2, may not be sufficient to enable the surplus water to drain from a cup in the manner described. Where this condition exists it is necessary that the cup compartment A should be deepened. This may be accomplished by increasing the depth of the dip plating above the dip channel, or by carrying the dip channel higher up relative to the tank water levels T_1 and H_1. In the case of existing holders, extensions to the dip may be effected by attaching plates or angles to the top of the dip channels, as indicated in Figure 5.

If the surplus water in the cup is to be prevented from over-running at the top of the dip, the following conditions must obtain:

(i) The highest level of the water A_1 in the cup of any lift of a fully inflated holder must be situated at a distance of not less than $(e-1)$ in. from the point of dip overflow when the corresponding water level B_1 is in line with the lower edge of the flooding holes or the lip of the curtailed cup plate. The value of $(e-1)$ represents the usual allowance for the action of the wind on the surface of the water in the exposed portion of the cup after deducting 1 in. for evaporation.

(ii) When a lift is approaching the cupping or uncupping position, the water level A_1 must not over-run the dip, i.e., the second critical position must not obtain.

It is not always convenient when designing gasholders to increase the height of the dips or extend the dip plating so as to prevent entirely any surplus water over-running the dip. In such instances, the special form of off-take pipe as shown in Figure 11(c) may be employed. These off-take pipes are fitted at equidistant points round the holder and allow the surplus water to drain away from the cup without interfering with the oil film on the exposed surface of the water.

Where a holder is oil-filmed inside so that dry gas may be stored, the surplus water from the cups cannot be allowed to drain away inside the structure during prolonged periods of wet weather. The continual running of the water from the cups of the inflated lifts tends to increase the humidity of the gas, and in such cases the cups must be designed to allow surplus water to be drained away over the dips of the lifts. The condition to be fulfilled may therefore be stated thus:

(i) The highest level of the water B_1 in the cup of any lift of a fully or partly inflated holder, must be situated at a distance not less than 1 in. from the bottom of the flooding holes or from the lip of the curtailed cup plating. This condition will ensure that surplus water will drain away via the dip, leaving a margin of 1 in. against water running into the holder.

There are no special conditions applying to the performance of the cups during the cupping and uncupping operations.

If the cups are allowed to " blow " at any time, a proportion of the oil film on the surface of the water inside the cup compartment B will be carried into the cup compartment A. In some cases, even where " blowing " of the cups does not occur, it has been found that a small quantity of filming oil may escape beneath the dip plating as the lifts uncup. This action is due to the extensive overpouring of the water when flooding the cup, as shown in Figure 6(b). This trouble, however, may generally be overcome by ensuring that the cup is flooded as early as possible during the process of uncupping.

To provide against the unsightly appearance of the paintwork on the side sheeting of a holder due to unrestricted over-running of the dips, it is desirable to employ off-take pipes. These pipes need not necessarily be constructed with a vertical leg reaching below the surface of the water in the cups as illustrated in Figure 16(b), unless oil filming of the cups is also required. However, in view of the fact that oil filming of gasholders is now practised extensively, not only for the purpose of storing dry gas, but also as a means of preserving the sheet and plate work, it appears preferable to design the cups of all holders in accordance with the following specification:

> " All cups to be so designed that surplus water due to rain, melting snow, or condensate from anti-freezing apparatus, will drain away over the dip. No surplus water will be allowed to drain away inside the holder, as the structure $\left\{\begin{matrix}\text{will be}\\\text{may be}\end{matrix}\right\}$ used for the storage of dry gas. Off-take pipes of approved design are to be fitted to the dips at equidistant points round the holder and so arranged that oil films on the cups will not be disturbed at any time while the holder is in commission ".

Perhaps the most serious disadvantage accruing from surplus

water draining away from the cups over the dip channels is that during frosty weather water leaving the cup may freeze on the outside of the lifts. In the case of spirally-guided holders, there is a possibility that the over-flowing water may freeze on the guide rails and so interfere with the working of the holder. To overcome this difficulty, the off-take pipes on the dips may be attached to fall pipes secured to the side sheeting of the lifts and lagged with water-proofed material. The amount of lagging on the pipe work, however, is generally small, owing to the restriction of space between the dips of the various lifts.

Another method of overcoming the difficulty with regard to water from the cups freezing on the guide rails, is to arrange for a certain quantity of water to be siphoned out of the cups each day during frosty weather, so that over-running of the dips, caused by condensate from the anti-freezing apparatus, is not likely to occur. This operation is obviously only practicable where the cups are of sufficient depth to provide a safe margin of seal after the necessary quantity of water has been removed.

Having regard to the foregoing conditions imposed on the draining away of surplus water from the cups of gasholders, it will be realized that the determination of flooding hole positions or curtailment of cup plating as determined by the dimensions X_1 or X_2 must be carefully checked in order to ensure the proper functioning of the cups and dips. The flooding hole positions or the extent of cup plate curtailment may, of course, be located in any plane between the dimensions X_1 and X_2 so long as the given conditions are satisfied. This procedure will also ensure that "blowing" of the cups does not take place during the cupping or uncupping operation.

X THE PRACTICAL DESIGN OF GASHOLDER CUPS

When designing the cups and dips of multi-lift gasholders, the following features require consideration:

(i) The width of the cup and dip compartments A, B and C.
(ii) The position of the lower edge or lip of the dip plating relative to the water level in the tank when all lifts are deflated and at rest.
(iii) The depth of the cup and dip plates.

When designing gasholder cups and dips, sufficient working clearance must be allowed between the side sheeting of the lift and any anti-freezing apparatus or water off-take pipes which may be fitted to the dip of the next lift. Care should also be taken to see that sufficient clearance is allowed between the cup and dip plates, and also between the cup plating and the vertical stays on the inside of the adjacent lift.

In the case of spirally-guided gasholders, the widths of the various compartments of any cup and dip are mainly dependent upon adequate clearance between the spiral rails on one lift and the dip plating of the subsequent lift. The final widths of the cup and dip are decided by the choice of the most suitable standard channel sections obtainable from the rolling mills. Narrow cups should be avoided where possible, as these are difficult to maintain and repair.

When determining the position of the lower edge or lip of the dip plating relative to the water level in the tank, it is considered desirable that the dip chambers should be sealed when the holder is completely out of commission. It is necessary, therefore, that the lip of the dip plating on any lift should extend slightly below the initial level of the water in the tank. The distance Q from the normal position of the tank overflow to the lip of the dip plating may then be ascertained as follows:

$$Q = p_a + 2 \quad \text{.....(42)}$$

The value of Q as here determined provides for the possibility of the tank being 1 in. out of level, and an allowance of 1 in. for loss of water due to evaporation has also been included. The seal on the dip compartments will be approximately Σ ( ), since the water level in the tank will rise by this amount when all lifts are grounded.

The depth of the cup and dip plating of any lift is dependent upon the following considerations:

(a) The maximum amount of seal available at the bottom of the dip plating when the holder is fully inflated. When designing cups of new holders a minimum seal of 6 in. should be provided.
(b) The maximum gas pressure thrown by the fully inflated holder (p_a).
(c) An allowance for the holder working out of level. In the case of new gasholders a subsidence of tank amounting to 1 in. and tilting of lifts amounting to 2 in. may be assumed.
(d) Allowances for evaporation and the action of wind on the surface of the water in the exposed portion of the cup. One inch is generally allowed for evaporation and a further allowance of $2\frac{1}{2}$ to 3 in. may be made for the action of the wind on the water in the cup. In cases where openings or run-off pipes are arranged in the extension of the dip plating above the dip channels, an allowance for wind of 2 in. only is sufficient, provided the top of the dip plating extends at least a further $2\frac{1}{2}$ in. above the overflow level.
(e) The minimum amount of seal available in the cup at the bottom of the dip plating during the uncupping operation. A minimum seal of 1 in. is usually considered sufficient as a margin against "blowing".
(f) The extent to which the depth of the cup and dip may require to be modified in order to comply with restrictions in regard to the disposal of surplus water from the cup, as in cases where oil filming is required.

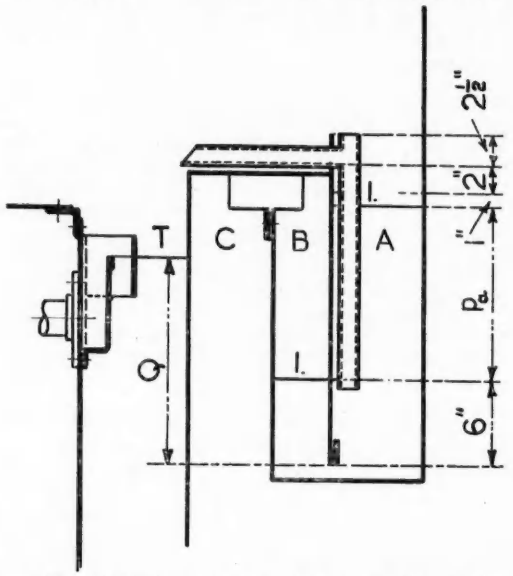

FIGURE 17.—*Preliminary Design of Cup and Dip Section for New Gasholder.*

The preliminary design of a cup and dip section may now be proceeded with as follows:

(1) Draw out the effective cup and dip section. An example is given in Figure 17, showing the method of provisionally determining the depth of the cup.

(2) Determine the highest and lowest levels of the water T_1 and H_1 and indicate the relative positions of these for the first critical stages in each set of cup and dip diagrams, as shown in Figure 10.

(3) Determine the critical stages from (I) to (VI) for the highest positions of the tank water levels T_1 and H_1.

If critical stage (II) is found to exist (i.e., water from the cup is found to run over the dip when the hanging lift is approaching the uncupping operation), then the point of dip overflow will require to be raised slightly; otherwise a full water seal of 6 in. will not be maintained if the flooding holes are placed in the lowest position, or the maximum curtailment of the cup plate is effected, as determined from the value of X_2. In this case the point of dip overflow should be raised to such an extent that the critical stage (II) does not exist, thus ensuring that no water will be lost from the cup during the uncupping operation.

(4) Determine the critical stages from (I) to (VII) for the lowest positions of the tank water levels T_1 and H_1.

(5) From these two sets of diagrams ascertain the values of X_1 and X_2.

(6) Check over the suitability of the positions of the flooding holes in the cup plating, or the extent by which it is proposed to curtail the cup plating.

(7) When detailing the final true cup and dip section, the amount by which the holder is assumed to be out of level must be added to the effective depth of the cup as shown by dotted lines in Figure 3. The final position of the flooding holes or the extent of cup plate curtailment, as indicated by the dimension from the underside of the rest block in the dip.

(*Continued on p. 170*)

Gas Products Prices

The London Market

Jan. 20.

There is no change to report in the prices of Tar Products in the London Market, and values remain to-day as follows : Pitch nominal ; creosote 4¾d. to 5d. per gallon ; refined tar 3¾d. to 4d. ; pure toluene under the Ministry of Supply Toluene No. 2 Order 2s. 5d. ; pure benzole 1s. 10d. ; 95/160 solvent naphtha 2s. 3d., and 90/160 pyridine 15s., all per gallon naked ; refined crystal naphthalene £23 per ton in bags ; all *ex* Makers' Works.

The Provinces

Jan. 20.

The average prices of gas-works products during the week were : Pitch and Crude Tar,* Toluole, naked, North, 1s. 10d. (controlled by the Control of Toluene No. 2 Order, July 5, which fixes the maximum price at which this material may be sold). Coal tar, crude naphtha, in bulk, North 9½d. to 10d. Solvent naphtha, naked, North, 1s. 9d. to 1s. 10d. Heavy naphtha, North, 1s. 5d. to 1s. 6d. Creosote, *ex* works, in bulk, North liquid and salty, 4¼d. to 4¾d. ; Scotland, 4¼d. to 4¾d. ; low gravity, 4¼d. to 4¾d. Fuel Grade 4d. to 4¼d. Carbolic acid, 60's, 3s. 9d. to 3s. 10¼d. Naphthalene, £15 to £20. Salts, 75s. to 85s., bags included. Anthracene, "A" quality, 4¼d. to 4¾d. per minimum 40% purely nominal. Heavy oil: Unfiltered anthracene oil (min. gr. 1,080), 5¼d. to 5¾d. ; filtered heavy oil (min. gr. 1,080), 5¾d. to 6d. ; heavy anthracene oil gr. less than 1,080, 6d. to 6¼d.

* In regard to pitch and crude tar prices we would ask readers to refer to the editorial note in our issue of Sept. 4, 1940, p. 404.

Tar Products in Scotland

GLASGOW, Jan. 18.

Market conditions show no material alteration during the week with fair quantities changing hands at current prices.

Refined tar is only in small request with home price unchanged at 4½d. to 4¾d. per gallon. Export supplies can be secured at 3¼d. to 3½d. per gallon, both f.o.r. naked.

Creosote oil is in good call at the following prices : Specification oil, 5d. to 5¼d. per gallon ; low gravity, 6d. to 6½d. per gallon ; neutral oil, 5¾d. to 6d. per gallon ; all *ex* Works in bulk.

Cresylic acid remains rather dull with supplies procurable as follows : Pale 99/100%, 2s. to 2s. 2d. per gallon ; Pale 97/99%, 1s. 9d. to 1s. 10d. per gallon ; Dark 97/99%, 1s. 6d. to 1s. 7d. per gallon ; all *ex* Works in buyers' packages.

Crude naphtha is readily disposed of as available at 6½d. to 7½d. per gallon *ex* Works in bulk, according to quality.

Solvent naphtha remains steady at 1s. 8½d. to 1s. 9d. per gallon for 90/160 grade and 1s. 4½d. to 1s. 5½d. per gallon for 90/190 heavy naphtha.

Pyridine is still very quiet with prices nominal at about 17s. to 18s. per gallon for 90/160 grade, and 19s. to 20s. per gallon for 90/140 grade.

Calendars, Diaries, &c., Received.

Seasonable gifts in the form of Calendars, Diaries, &c., have been received from the undermentioned friends, whose good wishes are cordially reciprocated :

The Standard Furnace & Setting Co., Ltd., Southport.

William Guppy & Son, Ltd., Eldon Street, E.C. 2.

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A.R.P.

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GAS STOCKS AND SHARES

Markets closed the week with a firm tone in the majority of sections, although the volume of business showed no signs of increasing British Funds remained quiet but steady and showed few changes—2½% Consols closing at 77½, the same level as a week ago. Home rails were strongly supported at the opening, and although there was less doing towards the end of the week, a number of prices showed fractional rises. A feature was the wide variety of industrial shares which were raised to higher levels, especially among the "heavies," while brewery and tobacco shares also hardened. Oils remained firm, and after a long period of inactivity more interest was taken in rubber shares.

As foreshadowed in this Report on several recent occasions, holders of certain gas stocks must doubtless be prepared for a disappointment this year. The first official indication is the postponement of the declaration of the half-yearly preference dividends by the directors of the Gas Light & Coke Company, and until the accounts for the past very difficult year are available holders of this stock will be uncertain of their fate. It is quite possible that other undertakings similarly placed may follow suit. The announcement naturally had an adverse effect on the price of the Company's units which at the opening weakened to 11s. 3d., but subsequently closed 1s. 9d. lower at 13s., while the 4% preference was 5 points down at 69½. A few other gas stocks reacted in consequence and these included the South-Eastern Gas Corporation £1 shares, which fell 1s. to 9s., and South Metropolitan ordinary with a drop of 5 to 50½. A sharp fall of 11½ occurred in Alliance & Dublin to 105½. On the other hand, it will be seen that in the Official List several fixed-interest stocks closed a few points higher. There were no changes of note on the Provincial exchanges or in the Supplementary List.

Quotations on the London and Provincial Stock Exchanges

OFFICIAL LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Jan. 16.	Rise or Fall on week.
1,767,439	Sept. 16	7	7	Alliance & Dublin Ord. ...	103—108	—11½
374,000	Dec. 30	4	4	Do. 4 p.c. Deb. ...	90—95	...
957,608	Nov. 4	5	5	Asscd. Gas & Water U'd'ts Ord.	11/6—13/6	—/6
500,000	,,	4½	4½	Do. 4½ p.c. Red. Cum. Pref.	14/6—16/6	—/6
335,545	,,	4	4	Do. 4 p.c. Red. Cum. Pref.	14/6—16/6	...
336,646	,,	4	4	Do. 4 p.c. Irred. Cum. Pref.	12/—14/—	...
561,370	Aug. 12	7	7	Barnet Ord. 7 p.c.	98—103	...
300,000	Oct. 14	1/9⅜	1/4⅜	Bombay, Ltd.	19/6—21/6	...
690,407	Aug. 19	7	7	Bournemouth 7 p.c. max. ...	100—110	...
362,025	Dec. 16	4	4	Do. 4 p.c. Deb. ...	79—84	...
659,955	Aug. 19	6⅜	4⅜	Brighton, &c., 5 p.c. Con. ...	65—75	...
855,000	Sept 30	8	6	Brit. Gas Light Ord.	75—85	...
545,000	Dec. 16	5½	5½	Do. 5½ p.c. 'B' Cum. Pref	105—115	...
120,000	,,	4	4	Do. 4 p.c. Red. Deb.	73—78	...
10,000	Nov. 6, '33	6	4	Cape Town, Ltd., 4½ p.c. Cu. Pf.	¼—¾	...
626,860	July 15	5 5/10	6	Cardiff Con. Ord.	89—94	...
24,500	Sept. 23	7	7	Colombo 7 p.c. Pref.	19/—21/—	...
764,169	Oct. 7	-/11.48	-/11.48	Colonial Gas Assn. Ltd. Ord. ...	14/—16/—	...
400,000	,,	1/3.30	1/3.30	Do. 8 p.c. Pref. ...	19/—21/—	...
1,748,935	July 22	2	3	Commercial Ord.	37—42	...
620,000	Dec. 9	3	3	Do. 3 p.c. Deb.	57—62	...
286,344	Aug. 19	5	5	Do. 5 p.c. Deb.	87—92	...
807,560	Aug. 12	7	6	Croydon sliding scale	83—88	...
644,590	,,	5	5	Do. max. div.	79—84	...
620,385	Dec. 30	5	5	Do. 5 p.c. Perp .Deb. ...	90—95	...
179,500	Aug. 19	5⅜	5	East Surrey 'B,' 5 p.c.	60—70	...
176,461	Dec. 16	5	5	Do. 5 p.c. Deb. (Irred.)...	87—92	...
250,000	Nov. 11	4	6	Gas Consolidation Ord. 'B' ...	13/6—14/6	...
250,000	Nov. 11	4	4	Do. 4 p.c. Red. Cum. Pref.	15/—17/—	...
19,123,018	July 29	3⅜	4½	Gas Light & Coke Ord. ...	12/—14/—a	—1/9
2,600,000	,,	3½	3½	Do. 3½ p.c. max.	50—55	...
4,477,106	,,	4	4	Do. 4 p.c. Con. Pref. ...	67—72	—5
2,993,000	July 8	3¾	3¾	Do. 3¾ p.c. Red. Pref. ...	82—87	...
8,602,497	Dec. 2	3	3	Do. 3 p.c. Con. Deb. ...	69—74	...
3,642,770	,,	5	5	Do. 5 p.c. Red. Deb. ...	100—105	...
3,500,000	,,	4½	4½	Do. 4½ p.c. Red. Deb. ...	99—104	+1
700,000	Sept. 9	3½	3½	Do. 3½ Red. Deb. ...	80—85	...
3,600,000	May 13	4	8	Imperial Continental Cap. ...	44—49	...
43,820	July 29	3½	3½	Do. 3½ p.c. Red. Deb. ...	61—66	...
231,978	Aug. 19	5	5	M.S. Utility 'C' Cons.	68—73	...
918,657	,,	4	4	4 p.c. Cons. Pref.	72—77	...
675,000	Nov. 11	†4	†4	Montevideo, Ltd.	52—57	...
300,000	Nov. 18	7	9	Oriental, Ltd.	105—115	...
368,537	Dec. 9	8	6½	Plymouth & Stonehouse 5 p.c.	88—98	...
621,667	Aug. 19	8½	7½	Portsmouth & Gosport Cons.	90—95	...
648,999	Sept. 16	1/1	1/1½	Severn Val. Gas Cor. Ld. Ord.	13/—15/—	...
597,972	,,	-/10⅝	-/10⅝	Do. 4½ p.c. Cum. Pref. ...	15/6—17/6	...
2,528,714	Sept. 2	1/—	-/7⅛	South East'n Gas Cn. Ld. Ord.	8/—10/—	—1/—
1,000,000	,,	-/10⅛	-/10⅝	Do. 4½ p.c. Red. Cum. Pref.	14/—16/—	...
1,068,869	,,	4	4	Do. 4 p.c. Irred. Cum. Pref.	12/6—14/6	...
6,709,895	Aug. 5	4	4	South Met. Ord.	48—53	—5
1,135,812	,,	6	6	Do. 6 p.c. Irred. Pref. ...	102—107	...
850,000	,,	4	4	Do. 4 p.c. Irred. Pref. ...	69—74	...
1,895,445	Dec. 30	3	3	Do. 3 p.c. Perp. Deb. ...	58—63	—2
1,000,000	Jan. 15	5	5	Do. 5 p.c. Red. Deb. ...	97—102*	...
1,543,795	July 22	3	4	South Suburban Ord. 5 p.c. ...	62—67	...
512,825	July 8	5	5	Do. 5 p.c. Perp. Pref. ...	85—90	...
500,000	,,	4	4	Do. 4 p.c. Perp. Pref. ...	63—68	...
250,000	,,	3¾	3¾	Do. 3¾ p.c. Red. Pref. ...	80—85	...
888,587	Dec. 16	5	5	Do. 5 p.c. Perp. Deb. ...	93—98	+3
750,541	Aug. 9	5½	5	Southampton Ord.	57—62	...
350,000	Feb. 12	5½	5½	Swansea 5½ p.c. Red. Pref. ...	91—96	...
1,076,495	Aug. 5	5	5	Tottenham & District Ord. ...	62—67	...
338,555	,,	5	5	Do. 5 p.c. Pref.	78—83	...
453,380	Dec. 9	4	4	Do. 4 p.c. Perp. Deb. ...	76—81	...
1,247,505	May 20	4	6	U. Kingdom Gas Cor. Ord. ...	13/—15/—	...
1,085,952	Nov. 25	4½	4½	Do. 4½ p.c. 1st Cum. Pref. ...	13/6—15/6	...
772,709	,,	4	4	Do. 4 p.c. 1st Red. Cum.Pref.	13/—15/—	...
745,263	Dec. 16	4½	4½	Do. 4½ p.c. 2nd Non.Cum. Pf.	12/—14/—	...
1,200,000	Sept. 9	3½	3½	Do. 3½ p.c. Red. Deb. ...	82—87	...
380,606	Aug. 5	7	6⅔	Uxbridge, &c., 5 p.c.	80—90	...
1,371,138	July 8	3½	4	Wandsworth Consolidated ...	66—71	...
2,525,768	,,	4	4	Do. 4 p.c. Pref.	63—68	...
1,343,964	Dec. 16	5	5	Do. 5 p.c. Deb.	90—95	+2
383,745	,,	4	4	Do. 4 p.c. Deb.	75—80	...
558,342	July 15	6	5	Watford & St. Albans Ord. ...	85—90	...
300,000	Dec. 9	3½	3½	Do. 3½ p.c. Red. Deb. ...	84—89	...

SUPPLEMENTARY LIST

Issue. £	When ex-Dividend.	Dividends. Prev. Hf. Yr. % p.a.	Dividends. Last Hf. Yr. % p.a.	NAME.	Quotations Jan. 16.	Rise or Fall on week
351,685	Dec. 16	5	5	Brighton, &c., 5 p.c. Perp. Deb.	88—93	...
28,700	,, 17	5½	5½	Do. 5½ p.c. Red. Deb. 1942...	95—100	...
415,250	,, 23	4	4	Bristol Gas Co., 4 p.c. New Deb.	83—88	...
140,205	July 29	7	7	Cambridge, &c., 7 p.c. Cons. 'B'	100—110	...
295,932	Aug. 19	5	5	Cheltenham, 5 p.c. Cons. Ord....	88—93	...
42,500	Dec. 16	4	4	Do. 4 p.c. Perp. Deb....	75—80	...
150,000	Aug. 12	4	4	Croydon Gas, 4 p.c. Pref. (Irr.)	65—75	...
130,000	Dec. 30	4	4	Do. 4 p.c. Deb. ...	75—80	...
146,700	Aug. 19	5½	5½	East Surrey, 5½ p.c. Pref. 'A' ...	80—90	...
53,220	,, 19	6	6	Do. 6 p.c. Cum. Pref. ...	90—100	...
117,425	Feb. 5	8	8	East Wight, 5 p.c. Cons. Ord. ...	100—110	...
...	Aug. 19	6	4	Eastbourne, 'B' 3½ p.c.... ...	65—75	...
239,135	Nov. 11	5	5	Gas Consolidation 'A' Ord. (£1)	13/—15/—	...
156,600	Aug. 19	5	5	Hampton C't, 5 p.c. Cons. Ord.	68—73	...
18,000	Dec. 2	7	7	Malta & Med'n., 7 p.c. 1st Pref.	55—65	...
10,845	,, 2	7½	7½	Do. 7½ p.c. 2nd Pref.	55—65	...
50,000	Aug. 19	£5 19 6	£5 4 6	Mid. South. Util., 'A' Cons. 5 p.c.	60—70	
65,000	Aug. 12	5	5	North Middlesex, 5 p.c. Pref. ...	87—92	...
70,000	Sept. 9	5	5	Plymouth & Stone., 5 p.c. Deb.	87—92	...
76,501	Dec. 30	4	4	Reading, 4 p.c. Perp. Deb. ...	75—80	...
74,777	Sept. 30	4	4	Romford, 4 p.c. Debs. (Reg.) ...	77—82	...
21,000	Dec. 16	5	5	Slough, 5 p.c. Perp. Deb. ...	87—92	...
211,740	,, 30	5	5	Southampton, 5 p.c. Red. Deb.	90—95	...
363,575	Dec. 30	5	5	Tottenham, 5 p.c. Reg. Red. Mt.	94—99	...
202,019	Oct. 14	6⅔	6⅔	Tunbridge Wells, 4 p.c. Scale ...	70—80	...
135,257	June 10	5	5	Uxbridge &c., 5 p.c. Perp. Deb.	88—93	...

PROVINCIAL EXCHANGES

					Quotations Jan. 10.	
47,756	July 26	6	5	Bath Cons.	94—98	...
122,577	July 22	7	6	Blyth 5 p.c. Ord.	100—105	...
1,667,250	July 15	5	5	Bristol, 5 p.c. max.	90—93	...
120,420	Dec. 16	4	4	Do. 1st 4 p.c. Deb.	92½—94½	...
415,250	,,	4	4	Do. 2nd 4 p.c. Deb. ...	91—94	...
328,790	,,	5	5	Do. 5 p.c. Deb.	107—110	...
157,150	Aug. 5	6½	5	Chester 5 p.c. Ord.	98—101	...
92,500	Dec. 16	4	4	Do. 4 p.c. Pref.	79—84*	...
36,430	,,	3½	3½	Do. 3½ p.c. Deb.	79—84*	...
41,890	,,	4	4	Do. 4 p.c. Red. Deb. ...	93—97*	...
542,270	Aug. 12	9	6	Derby Cons.	100—105	...
55,000	Dec. 16	4	4	Do. 4 p.c. Deb.	77—82	...
10,000	Aug. 19	10	10	Great Grimsby 'A' Ord. ...	165—175	...
6,500	,,	10	10	Do. 'B' Ord. ...	165—175	...
79,000	,,	10	10	Do. 'C' Ord. ...	155—165	...
732,000	Aug. 26	4	4	Hartlepool G. & W. Cn. & New	61—63	...
2,167,410	Aug. 19	6	6	Liverpool 5 p.c. Ord.	97—100	...
245,500	Dec. 16	5	5	Do. 5 p.c. Red. Pref. ...	97½—100½	...
306,083	July 15	4	4	Do. 4 p.c. Deb.	99—101	...
20,000	Dec. 23	5	5	Long Eaton 5 p.c. Pref. ...	9—11	...
80,000	,,	5	5	Do. 5 p.c. Deb.... ...	92—97	...
2,430,267	July 29	5 7/10	5	Newcastle and Gateshead Con.	16/3—17/3a	...
682,856	,,	4	4	Do. 4 p.c. Pref.	75—77	...
776,706	Dec. 23	3½	3½	Do. 3½ p.c. Deb.... ...	80—85	...
277,285	Oct. 21	5	5	Do. 5 p.c. Deb. '43 ...	97—102	...
274,000	July 26	5	5	Newport (Mon.) Ord.	89—93	...
13,200	Sept. 16	8⅝	7	Pontyp'l Gas & W. 10 p.c. 'A'	11½—12½	...
13,600	,,	6	5	Do. 7 p.c. 'B'	9½—10½	...
40,000	,,	5	6	Do. 7 p.c. 'C'	9½—10½	...
106,280	Aug. 5	8	10	Preston 'A' 10 p.c.	157—167	...
188,219	,,	7	7	Do. 'B' 7 p.c.	113—123	...
1,806,339	Aug. 26	6½	6½	Sheffield Cons.	118—120	...
95,000	Jan. 6	4	4	Do. 4 p.c. Deb.	96— 98*	—1
332,351	Feb. 5	6	6	Sunderland 6 p.c. max. ...	107—112	...
140,778	Aug. 12	5	5	Weston-super-Mare Cons. ...	80—85	...
64,338	Dec. 30	4	4	Do. 4 p.c. Deb.	75—85	...
33,340	,,	7½	7½	Do. 7½ p.c. Deb.	135—143	...

a.—The quotation is per £1 of Stock. * Ex. div. † Price free of income-tax.

remains the same as for the effective section of the cup and dip. If, therefore, an allowance of 2 in. is made for the tilting of the lifts as they approach the uncupping operation, the actual depth of the cup will be 2 in. greater than the effective depth.

XI ANALYSIS OF EXISTING CUP AND DIP SEALS

Although the foregoing investigation deals principally with the modern design of gasholder cups and dips, the method of treatment may be readily applied when studying the performance of the cup and dip seals of existing holders. In some of the older gasholders, it may be found that "blowing" takes place each time lifts are uncupped. This and other unfavourable features in the cups of existing holders may be rectified after a careful examination of the cup and dip under actual working conditions. When carrying out such investigations on cups and dips, it is not necessary to calculate the positions of the water levels in the cups and tank for the various critical stages, as these may, if desired, be ascertained directly from actual measurement. Some simple apparatus is required, however, for the purpose of obtaining the position of water levels and gas pressures.

The uncupping operation should first be studied. The holder is lowered to a convenient position so that a small gas connexion may be made in the side sheeting of the inside lift. A similar gas connexion is then made in the dip channel or plating of the adjacent lift. These connexions should be made at the highest point of the lift, so that during the uncupping operation any tendency to "blow" may be observed. Two pressure gauges are fitted with flexible tubes to the gas connexions in the side sheeting of one lift and the dip of the adjacent lift. Two vertical scales are also arranged on either side of the dip so that measurements may be taken of the rise or fall in the water levels in the cup and tank at the various stages when the lifts uncup. A scale is also attached to the sheeting of the inside lift and allowed to rest on the bottom of the cup.

The general arrangement of the apparatus described above is shown in Figure 18.

Before observations are taken, the water in the tank should be at its highest possible level so as to represent the most unfavourable conditions for the uncupping operation. A quantity of water must, if necessary, be siphoned from the cup so as to represent the most unfavourable condition possible so far as the cup seal is concerned, i.e., the level of the water A_1 must be $(e+e_1)$ in. from the point of dip overflow on the lowest side of the lift.

After lowering the cup and dip in question to within a few inches of the first critical stage, the holder is ready for observations to be made on the operation of the seal. The gas pressures on the gauges are noted and records are taken of the distances from the top of the dip to the water levels in compartments A and T. The holder is then gradually deflated. When the first critical stage is reached, observations are again made of the pressures in the holder and in the dip chamber. It should be noted that the first critical stage obtains when the bottom of the cup on the highest side of the lift is known to be just in contact with the water level in the tank (H_1). The distance from the top of the dip to the water level in the tank (T_1) is also noted.

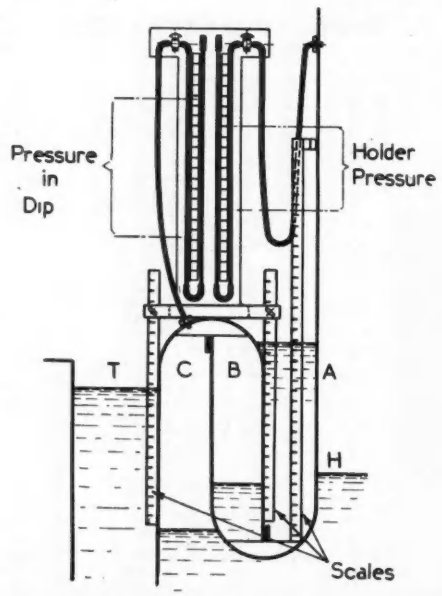

FIGURE 18.—*Apparatus for the Practical Analysis of Cup Seals of Existing Gasholders.*

As the holder descends, a watch is kept for the second critical stage. If this stage exists, further records of the gas pressure inside the holder and in the dip are taken as soon as water is found to flow over the dip from the cup compartment A on the low side of the lift. The measurement from the top of the dip on the low side of the lift to the water level in the tank compartment T is also noted. When the third critical stage obtains, the dip will remain stationary and the distance from the top of the dip to the water level in the tank compartment T is then noted. The water levels in compartments A and T now fall until the possible fourth critical stage is reached. It is difficult to observe when this stage exists, as it is only apparent from external examination by a relatively greater fall of the water level in compartment A compared with the fall of the water level in compartment T. The fifth critical stage is eventually reached when the water level in the tank compartment T has fallen by the amount equal to the pressure of the landed lift (p_h). This position may be checked by measurement from the scale. As the holder continues to fall, the sixth critical stage is reached, when "blowing" of the cup may occur. The water levels in compartments A and T should be observed from the scales and the distance the cup has moved may also be read from the scale resting in the cup. After the uncupping operation is completed and any "blowing" of the cup has subsided, the cupping operation may be examined. The holder is then gradually inflated after reducing the depth of the water in the tank to allow for evaporation, etc. A point is eventually reached where the level of the water in compartment A is at the same level as the water in the tank compartment T. These levels are observed on the vertical scales on either side of the dip and represent the position of the cup and dip at the seventh critical stage. When the necessary pressures and measurements have been recorded, diagrams of the effective sections of the cup and dip are then prepared, showing the water levels at the various critical stages. These showing the water levels at the various critical stages.

To overcome the difficulty with regard to determining the various critical stages while taking records of the cupping and uncupping operations on an existing holder, continuous readings may be taken of the gas pressures and water levels covering the completed movement of the cup and dip. A set of readings consisting of water levels and gas pressures may be recorded in a few seconds, and if these are tabulated it is a simple matter to take about 50 sets of readings during the time the holder is uncupping. Continuous readings may also be taken when studying the performance of the cups during the cupping operation. The sets of readings may then be analysed and the water levels set out on large-size diagrams of the effective cup and dip section. These diagrams may then be examined in the usual way to ascertain whether it is necessary to drill flooding holes in the cup plates, increase the depth of the dip, or make any other modification that may appear desirable to improve the working of the cup and dip.

APPENDIX

LITERATURE REFERENCES

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[3] Correspondence in *J. Gas Lighting*, 5th March to 30th April, 1889.

[4] "Gasholder Cups", *J. Gas Lighting and Water Supply*, 5th April, 1910.

[5] "Über die Wirkungsweise der Gasbehältertassen", *Journal fur Gasbeleuchtung und Wasserversorgung*, 30th March, 1912.

[6] "Die Druckbewegung in Gasbehältern und Gasbehältertassen in Theorie und Praxis", *Journal fur Gasbeleuchtung und Wasserversorgung*, 16th and 23rd November, 1912.

[7] "Über mangelhafte und einwandfreie Arbeitsweise der Tassen teleskopierter Gasbehälter", *Gas- und Wasserfach*, 3rd and 10th September, 1932.

[8] Thompson, M. A., "A Method of Locating Flooding Holes in Gasholder Cups", *Gas J.*, 1935, **209**, 576.